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U. S. NAVAL ORDNANCE LABORATORY

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SILVER SPRING, MARYLAND

To all holders of NOLTR 62-30 — Change 1
insert change; write on cover 'Change 1 inserted' — 5 November 1962
Approved by Commander, U.S. NOL — 1 page

J. M. K...
By direction

This publication is changed as follows:

1. Page iii, last line, change "Fig. 22. Test Set Mk 209 Mod 1" to read "Fig. 22. Test Set, Drop Shock, WOX 126A".

2. Page 33, under designation, change "Test Set Mk 209 Mod 1" to read "Test Set, Drop Shock, WOX 126A".

3. Page 42, change title "Fig. 22. Test Set Mk 209 Mod 1" to read "Fig. 22. Test Set, Drop Shock, WOX 126A".

4. Page 42, line 15, change "Mod 1" to read "WOX 126A".

5. Page 42, line 16, change "Mod 1" to read "WOX 126A".

Insert this change sheet between the cover and the title page of your copy.

63-1-1

NOLTR 62-30

PRINCIPAL LABORATORY TEST FACILITIES OF THE ENVIRONMENT SIMULATION DIVISION, NOL

2 AUGUST 1962

NOL

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 62-30

PRINCIPAL LABORATORY TEST FACILITIES OF THE ENVIRONMENT SIMULATION DIVISION, NOL

Prepared by
W. C. Brueggeman
Environment Simulation Division

ABSTRACT: This report presents a brief description with photographs of the principal test facilities of the Environment Simulation Division, NOL. Basic information on capacity and performance is included. The principle of operation is briefly explained where this is not obvious. The report is expected to be valuable for training new design and evaluation engineers of the Laboratory and in serving as a handbook while they are developing test programs.

PUBLISHED SEPTEMBER 1962

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

NOLTR 62-30 2 August 1962

Principal Laboratory Test Facilities of the
Environment Simulation Division, NOL

This report is intended to fill a need, which has been evident for some time, for descriptive material on the test facilities of the NOL Environment Simulation Division. The principal uses of the report will be to train new employees and to serve as a catalog for the information of the NOL engineering staff.

R. E. ODENING
Captain, USN
Commander

V. M. Korty
V. M. KORTY
By direction

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TABLES

Chapter 1

INTRODUCTION

The environmental test facilities of the Environment Simulation Division, Environmental Evaluation Department are all located on the Naval Ordnance Laboratory base at White Oak, Maryland, mostly in Building 20, figure 1. Procurement of the facilities began during World War II while the Laboratory was located at the Naval Gun Factory in Washington, D.C.

Some of the facilities have been obtained commercially as stock items, some have been built on contract from NOL designs and others have been designed and built at NOL. Many are unique in their principle of operation, capacity, or performance.

Most of the shock test facilities, except those known as "launchers", are described in NOLR-1056. Heretofore, no report on all the environmental test facilities of the Division has been available.

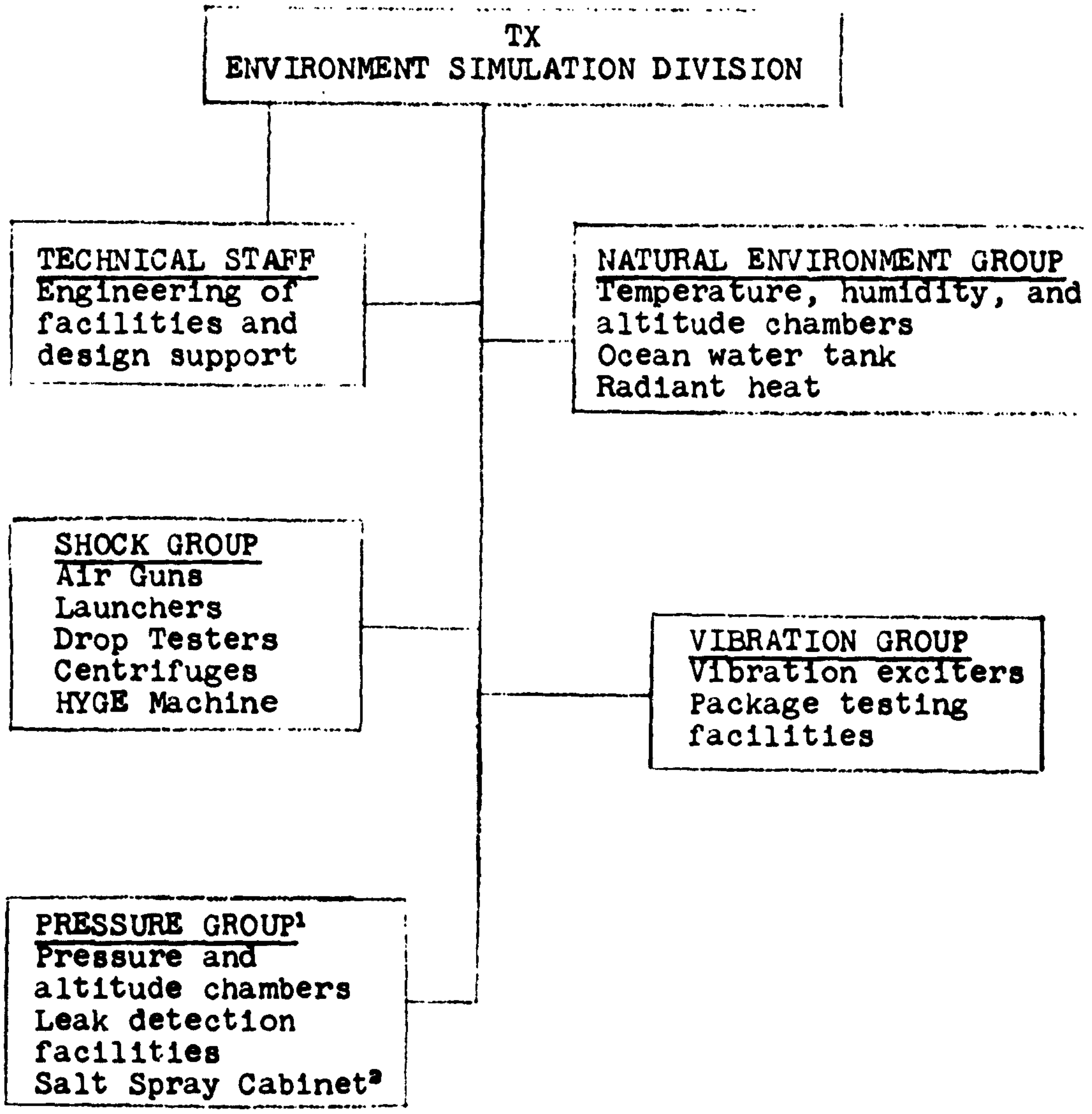
Because of its comprehensive nature it is impracticable to include in this report more than the most general description of the principles of operation and design. Emphasis is placed on presenting significant and important facts regarding the basic principles, capacity, and application of the facilities rather than completeness of detail. It is hoped that the description of the test facilities will be interesting and valuable even to persons who are not well versed in environmental testing.

Reference is given to other reports, where available, on specific facilities. The facilities are presented roughly by group areas, figure 2, where the facilities are located. The negative file number assigned by the Photographic Division appears on most of the photographs.

Other environmental test facilities are in use in the Laboratory in areas outside the Environment Simulation Division. Examples are wind tunnels, aeroballistic ranges, sources of radiation, the mine tank, and facilities used by the Operations Division of the Air and Surface Evaluation Department for safety tests of small explosive or pyrotechnic components. These are outside the scope of this report.

5-2268

FIG. 1 ORDNANCE ENVIRONMENTAL LABORATORY, BLDG. 20
NOL, WHITE OAK



[1] Technically, pressure is a natural environment, but the Pressure Group is a distinct unit in the Division organization.

[2] Corrosion testing is performed by the Pressure Group, although corrosion is the result of the natural environment.

Fig. 2. Facility Location in the Environment Simulation Division

Chapter 2

NATURAL ENVIRONMENT

TEMPERATURE, HUMIDITY, AND ALTITUDE

The temperature test is the most widely used of all environmental tests and the chamber for maintaining the test temperature is the most common item of test equipment. Almost any test requirement can be met from the variety of chambers on hand. The temperature range for most chambers is -100 to 200°F. Ovens are used for higher temperatures. Means for controlling the humidity and simulated altitude are built in to some of the chambers. Special arrangements are made as shown to simulate aerodynamic heating.

Fig. 3. NOL Walk-in Climatic Chamber

This chamber, the largest of its kind in the Laboratory, has usable space 8 1/2 ft wide by 8 1/2 ft high by 30 ft long. There is a full opening hydraulically elevated door at each end; a removable partition at midlength provides two separate 14 1/2-ft-long chambers which may be operated independently of each other at different temperatures. The temperature may be controlled over the range -100°F to 200°F and the relative humidity from 20% to 95% above 40°F. Observation windows, communication ports, and thermocouple connections facilitate remote control, operation, measurement, and visual observation. Entrance locks for each chamber allow entry and exit of personnel during tests without disturbing chamber conditions. Heated cold weather suits and ventilated hot weather suits are available for personnel to wear. The temperature and relative humidity in each chamber may be automatically raised or lowered at a variable rate by the use of a pattern controller.

Manufacturer: Arthur E.Magher Company

Location: Room 20-158

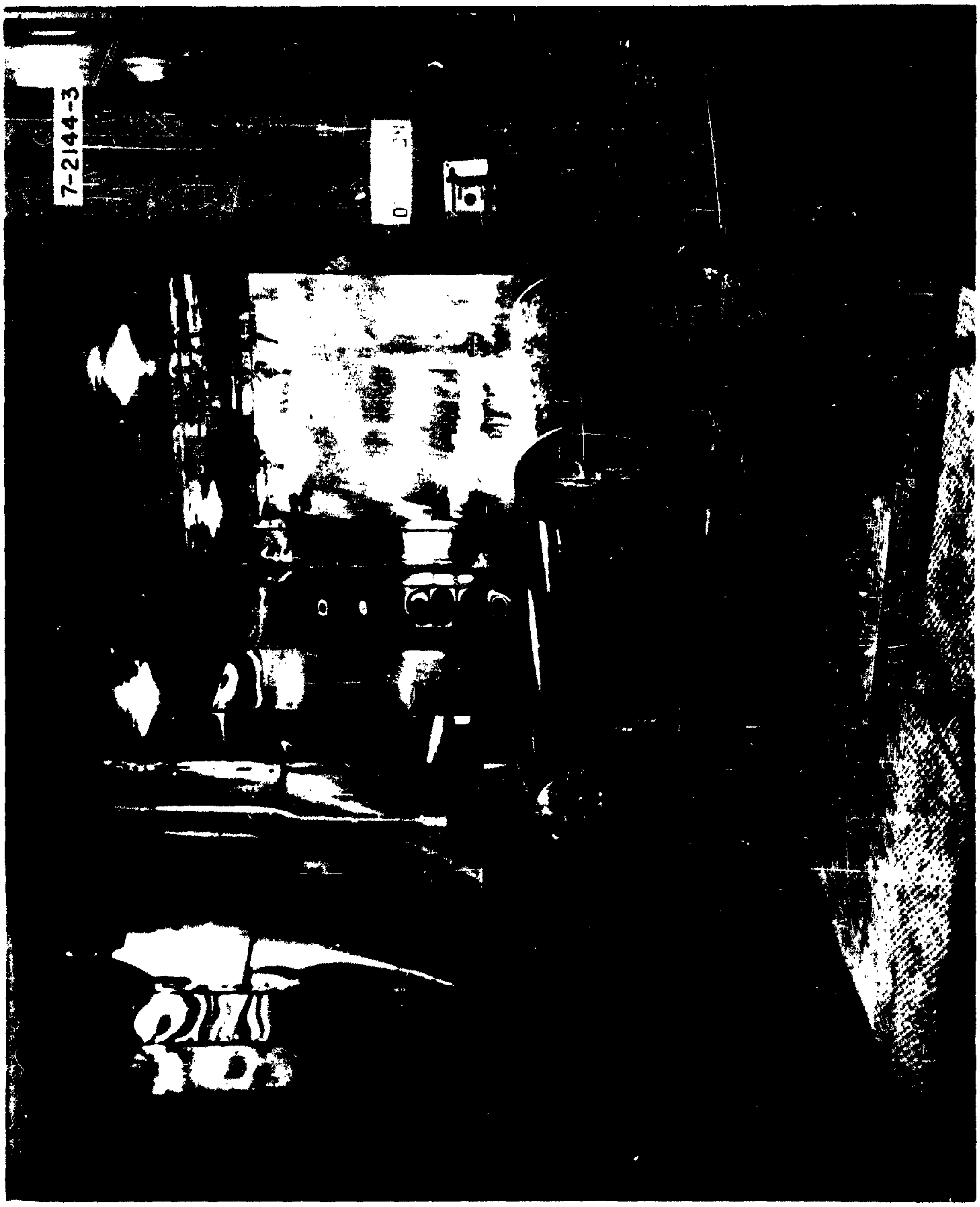


FIG. 3

Fig. 4. Temperature, Humidity, and Altitude Chambers

Many chambers are available for conditioning and storing ordnance at temperatures ranging from -100°F to 300°F with automatic control. Most have means for varying the relative humidity through the range 20% to 95% at temperatures above 40°F. Altitude may be simulated in some of the chambers. Typically, a degree of vacuum corresponding to an altitude of 100,000 ft is attainable in 10 min. The typical size of the work space is 30 x 30 x 30 in.; one larger chamber has work space 36 x 36 x 84 in. Ovens are available for hot storage tests at controlled temperature up to 500°F. All chambers except the Walk-In Chamber and some ovens are commercial models.

Location: Room 20-158

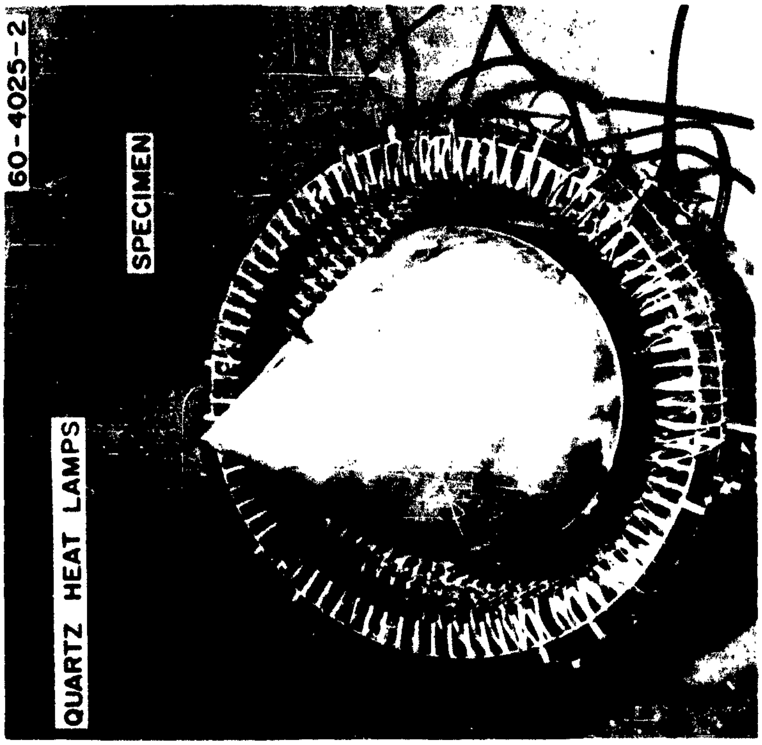
FIG. 4

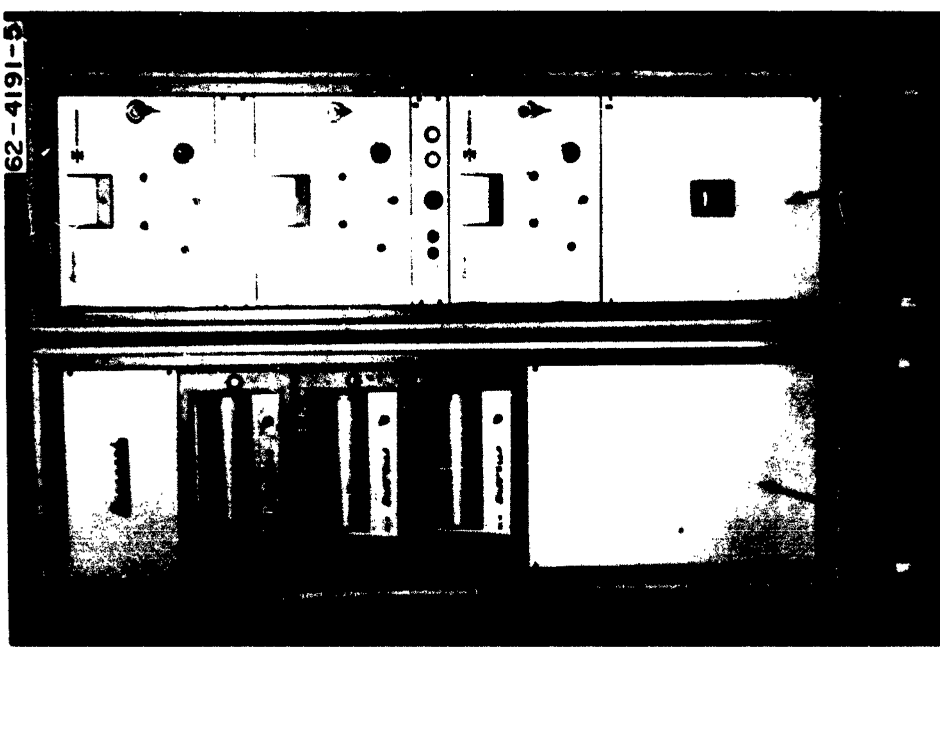
Fig. 5. Radiant Heating Test Facility

Aerodynamic heating of missiles is simulated by means of an array of heat lamps which surround the specimen and radiate heat to it. The number of lamps and the spacing are determined and set up for each particular test.

A three-channel DATATRAC unit is installed for controlling the current supplied to the heat lamps. The temperature may be programmed from a curve drawn on the rotating drum. The power capacity of the equipment for each channel is 210 KVA but at the time of this report the total available capacity is only 300 KVA.

Location: 20-158





POWER REGULATOR

DATATRAC PROGRAMMER

FIG. 5

IMMERSION

Fig. 6. Ocean Water Immersion Tank

This tank holds 25,900 gallons, is located indoors adjacent to the Walk-in Climatic Chamber, and has several functions as follows:

1. Provides a convenient indoor means for observing actuation and performance of ordnance at depths up to 15 ft.

2. Contains water at controlled temperature for thermal shock and heat transmission tests.

3. Provides a reservoir of water at controlled temperature, when such is required, for the 8 x 30 ft Horizontal Pressure Vessel.

4. Provides a facility for immersion tests to determine susceptibility to corrosion in sea water.

The tank is rectangular, 38 ft long, and 8 1/2 ft wide. The depth is 15 ft for one-half the length and 9 ft for the other half. Observation windows are built into the walls and portable underwater lights are available. The water may be recirculated through temperature conditioning equipment and may be agitated within the tank to maintain any temperature within the range 40-100°F to within 1°F at any point in the tank. Either fresh water or synthetic sea water may be used.

Location: Assembly Area Building 20

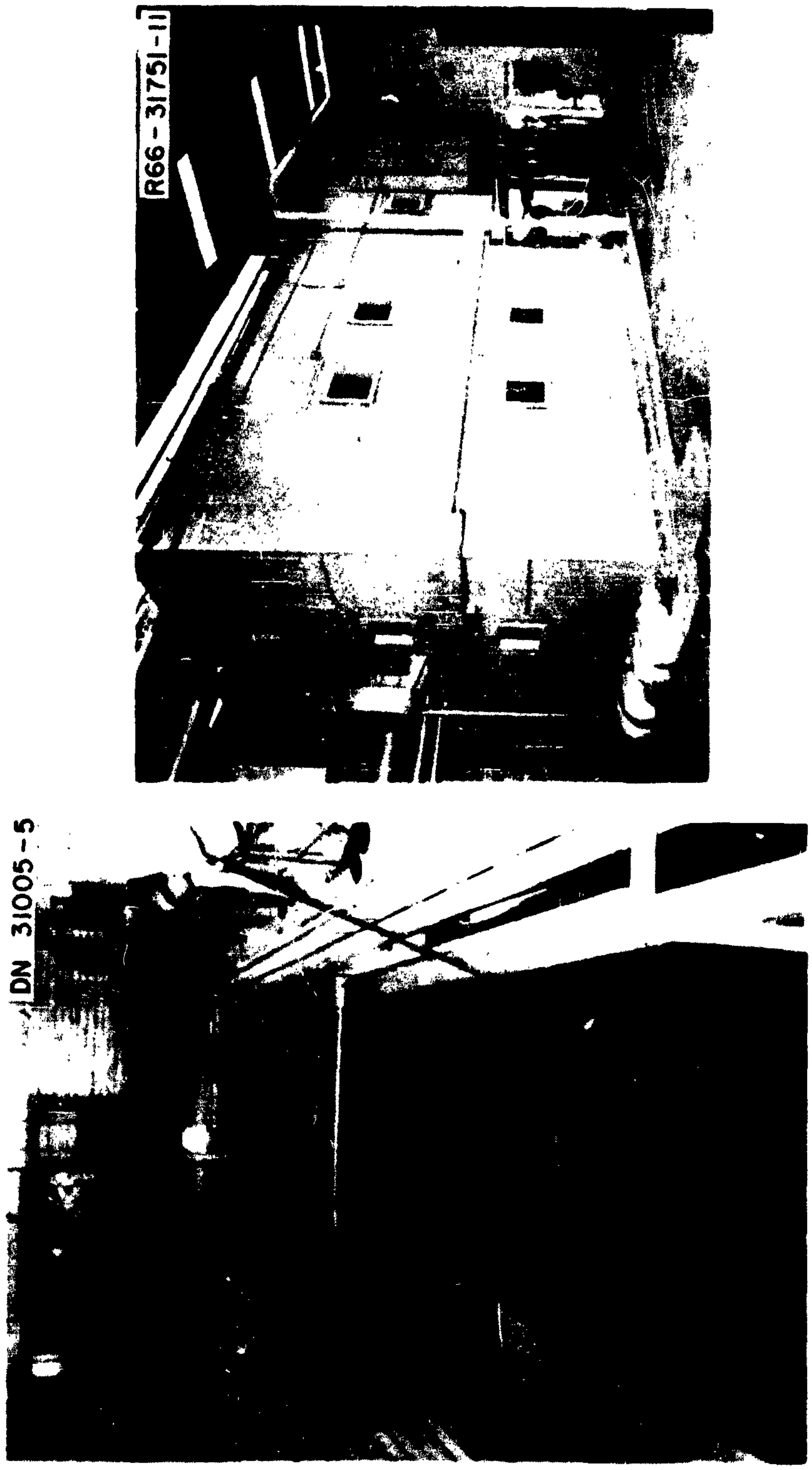


FIG. 6

CORROSION

Two types of laboratory tests are used in the Division to determine susceptibility to corrosion and deterioration from exposure to sea water or the atmosphere. These are salt spray and immersion tests. In addition, arrangements can be made for uncontrolled long-term atmospheric exposure at selected field locations. Desert, tropical, marine, arctic, and local environment can be provided.

A description of the Salt Spray Cabinet is given in Figure 7. Immersion tests are carried out in a suitable vessel, frequently in the Ocean Water Immersion Tank, Figure 6. Synthetic sea water is generally used.

Fig. 7. Salt Spray Cabinet

The salt spray test is a widely used means for determining the resistance of components and assemblies to corrosion. The corrosion is accelerated but is similar to that occurring in marine environments, for example, on a beach or flight deck. The test is usually performed as specified in ASTM Standard B-117-49T in the cabinet shown in Figure 7. Specimens are suspended in the cabinet. A controlled salt fog is maintained inside by means of atomizing nozzles supplied with salt solution and compressed air. The temperature is maintained at 95°F and the relative humidity between 84 and 90 percent. Usually the exposure time is 96 hours.

Manufacturer: Industrial Filter and Pump Manufacturing Co.

Model: CW-1

Inside dimensions: 48 x 34 x 25 in.

Location: 20-033

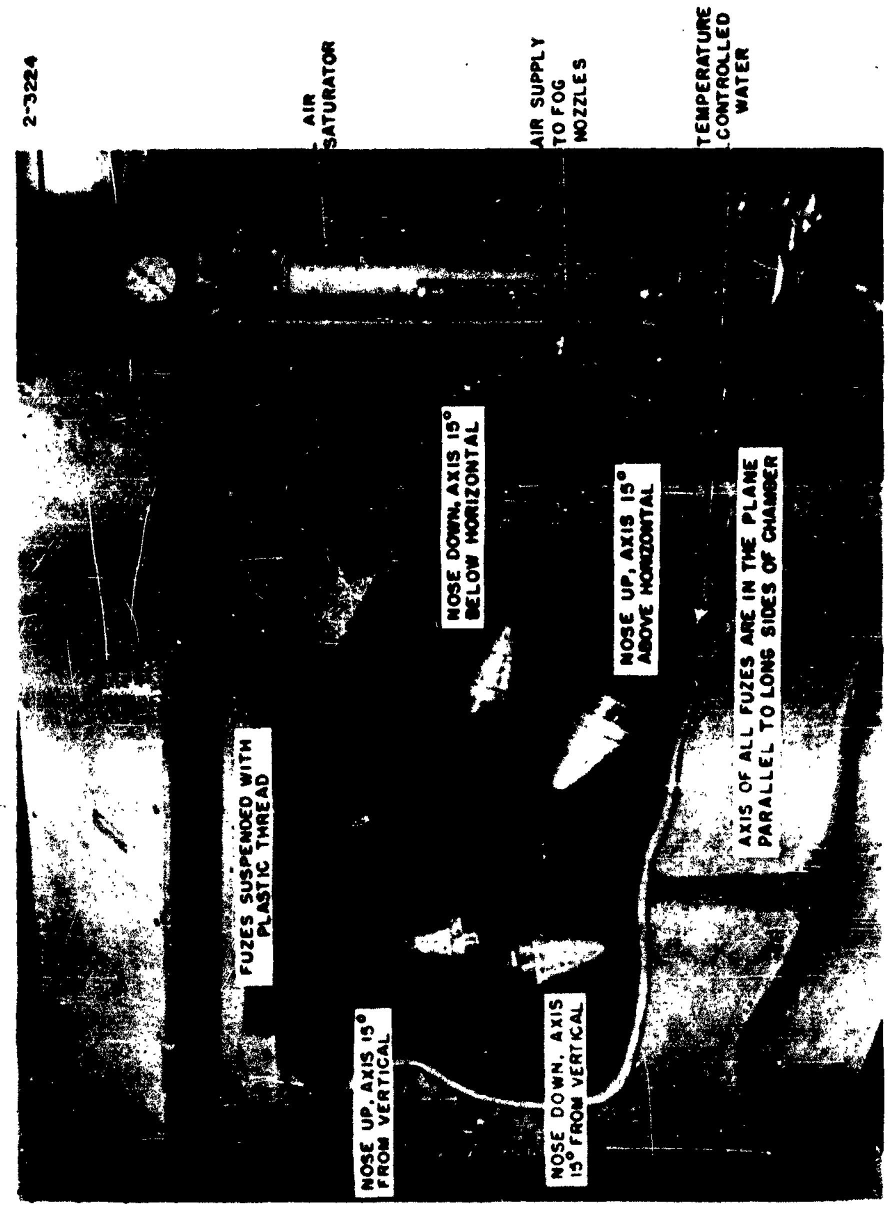

2-3224
AIR SATURATOR
AIR SUPPLY TO FOG NOZZLES
TEMPERATURE CONTROLLED WATER
NOSE DOWN, AXIS 15° BELOW HORIZONTAL
NOSE UP, AXIS 15° ABOVE HORIZONTAL
AXIS OF ALL FUZES ARE IN THE PLANE PARALLEL TO LONG SIDES OF CHAMBER
FUZES SUSPENDED WITH PLASTIC THREAD
NOSE UP, AXIS 15° FROM VERTICAL
NOSE DOWN, AXIS 15° FROM VERTICAL

FIG. 7

Chapter 3

MECHANICAL SHOCK

Shock tests are performed in the Laboratory in many different ways and for the purpose of simulating many service conditions. Among the tests most frequently performed are those simulating water impact, countermining, target impact, ground impact, nearby underwater explosion, parachute opening, launching or firing setback, and rough handling. Obviously these require acceleration pulses varying widely in shape with considerable range of peak value and duration. The specimens vary greatly in size and weight.

The shock test facilities fall into only two classes, those employing the release of a piston under air pressure to produce controlled acceleration, and those employing impact. Details of the principles of operation and the performance of most of these facilities are given in NOLR-1056.

AIR GUNS AND HYGE MACHINE

The air gun belongs to the released-piston class of shock test facility. In elementary form it consists of a long tube closed at both ends, a piston on which the test specimen is mounted, and a device located near the breech end for mechanically releasing the piston under load. Air pressure commensurate with the required accelerating force is built up in back of the piston, the piston is released, experiences acceleration, then is cushioned and eventually brought to rest by air trapped in the muzzle.

Air guns are high-energy devices combining fast build-up of acceleration, relatively long duration of acceleration when required, and high payload capacity. Accessory fixtures are frequently used to provide a two-phase shock simulating that accompanying entry of a missile or mine in water at high velocity. This is accomplished by introducing a steel-on-steel impact immediately after piston release thus adding a high-amplitude short-duration spike to the regular pulse. The characteristics and performance of the five NOL Air Guns are given in Table 1. NOLR-1056 should be consulted for details.

The HYGE Shock Tester is a commercial shock testing facility which employs a piston accelerated by compressed air. The test specimen is externally mounted.

Table 1. Characteristics and Performance of NOL Air Guns

Model- (Bore Diam) in.	Barrel Length ft	Bore Area sq in.	Max. Chamber Volume cu ft	Max. Breech Press. psi	Muzzle Press. psi	Max. Accel'g Force lb	Max. Velocity Piston fps	Theoretical Max. Load lb	Theoretical Accel'n Accel.* g	Acceler'n Rise Time * ms
26	90.2	531	1.5-30	10,000	0-1000	5310000	**	4000	1000	**
21	93.3	340	2.5-11.5	1,000	-12 to 90	340000	800	10 100 200	2100 1350 1000	1 to 10
15	58	173	1.38 or 1.8	1,000	0-90	174000	450	10 100 200	2300 1000 650	1 to 10
5	95	19.6	.05	15,000	0-300	290000	750	1 2 5	45000 39000 27000	.1 to .3
2	53	3.15	.024	15,000	0-1000	44000	750	.01 .1 .5	200000 145000 60000	.1 to .25

*For single-phase shock. Two-phase shock tests may also be performed in the 26-, 21-, and 15-in. air guns.

**Values not yet available.

Fig. 8. NOL 26-in. Air Gun

This large shock test facility, shown at its temporary site, is still under development at the time of this report, but was placed in limited use for testing ordnance in the summer of 1961. The bore diameter, payload capacity, and available accelerating force are sufficient for tests of many full-size weapons and weapon systems as well as large components. This facility is expected to provide early design data on systems and components of systems, which should improve their performance in field tests and eliminate some field tests entirely. Sufficient experience with the gun has not yet been obtained that detailed performance figures may be presented.

Single-phase and two-phase shock tests may be performed as in other NOL air guns. In addition, when installed at its permanent site, the gun may be fired with open muzzle to accelerate a missile for impact against a nearby target. Studies of the effects of impact against targets and possibly against water will thus be made.

The gun is constructed from the barrels of two 16-in./50 Naval guns. A portion of each barrel was cut off at the muzzle end, a flange was welded on, and the bore was enlarged to 26 in. The gun is mounted on four railroad car trucks. The first type of piston release to be employed is a notched tubular breaklink designed to break in tension at a load slightly greater than the desired accelerating force. Static air pressure is built up behind the piston to produce this force. Fracture of the link is initiated by firing an explosive cartridge. Another type of release has been constructed in which the butt of the piston is unseated from a sealing member to admit the accelerating pressure. This release was ready to install at the time of this report.

The means for obtaining so-called two-phase or water-entry shock are evident in figure 8. The test specimen is connected to the "JANUS mass" by a loose linkage which permits a clearance as great as 0.3 in. between the two units. When the gun is fired the "JANUS mass" moves this distance before colliding with a plate rigidly connected to the specimen. The resulting impact produces a spike-shaped pulse of acceleration which is the first phase. Both units then move together down the barrel for the second or drag phase at lower but longer-sustained acceleration. JANUS is the two-faced god of ancient Rome. Thus, the piston for two-phase shock is naturally called the JANUS piston. Another type of piston has been constructed in which the JANUS mass is locked by detents

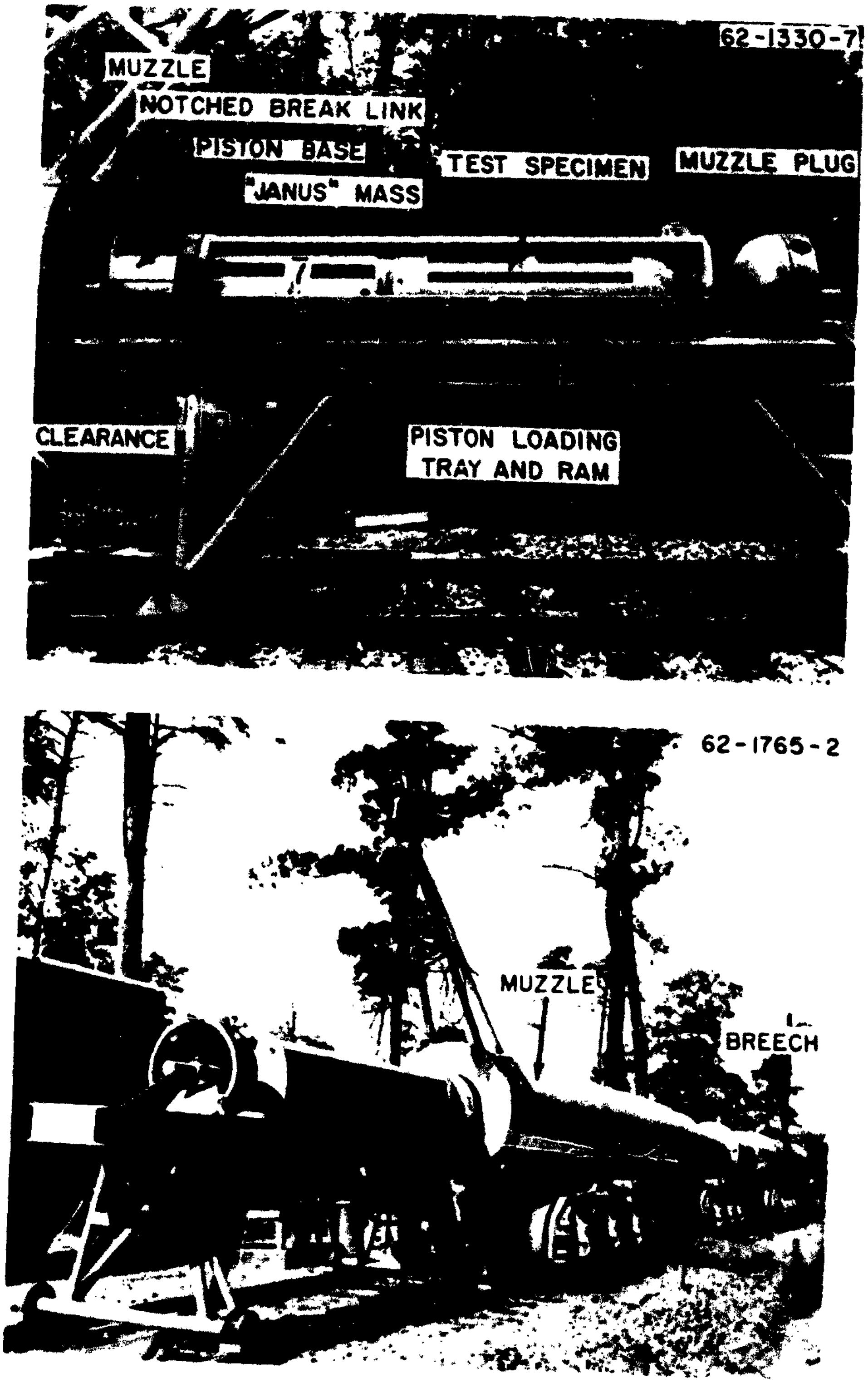

62-1330-7
MUZZLE
NOTCHED BREAK LINK
PISTON BASE
"JANUS" MASS
TEST SPECIMEN
MUZZLE PLUG
CLEARANCE
PISTON LOADING
TRAY AND RAM
62-1765-2
MUZZLE
BREECH

FIG. 8

to the specimen mounting base upon collision. This type allows only one collision and has been used in other guns.

The temporary site of the gun is located off Dahlgren Road near Paint Branch at White Oak. Development of a permanent site nearby to include a building is in progress.

Fig. 9. NOL 21-in. and 15-in. Air Guns

The 21-in. air gun was installed in 1948 and has had extensive use in shock tests of many types of ordnance, particularly for components of underwater ordnance. The breech assembly permits adjustment of the volume of air behind the piston. The details of the release mechanism are not given here but may be found in NOLR-1056. Formerly, steel locking balls were used in this mechanism to hold the piston back. These have been replaced by caged disks, resulting in increased load capacity and service life. Most of the tests made in this gun require two-phase shock. This gun is equipped with a muzzle tank into which air flows as the piston travels down the barrel. The air is trapped in this tank by flap valves as the piston reverses direction. Thus, the reverse acceleration and the number of oscillations before the piston comes to rest are minimized. Six insulated brass strips running the full length are installed inside the barrel for electrical communication with the piston. Brushes mounted on the piston bear against the strips as the piston moves in the barrel.

The 15-in. air gun is generally similar to the 21-in. It has no muzzle tank and is adjustable to only two breech volumes.

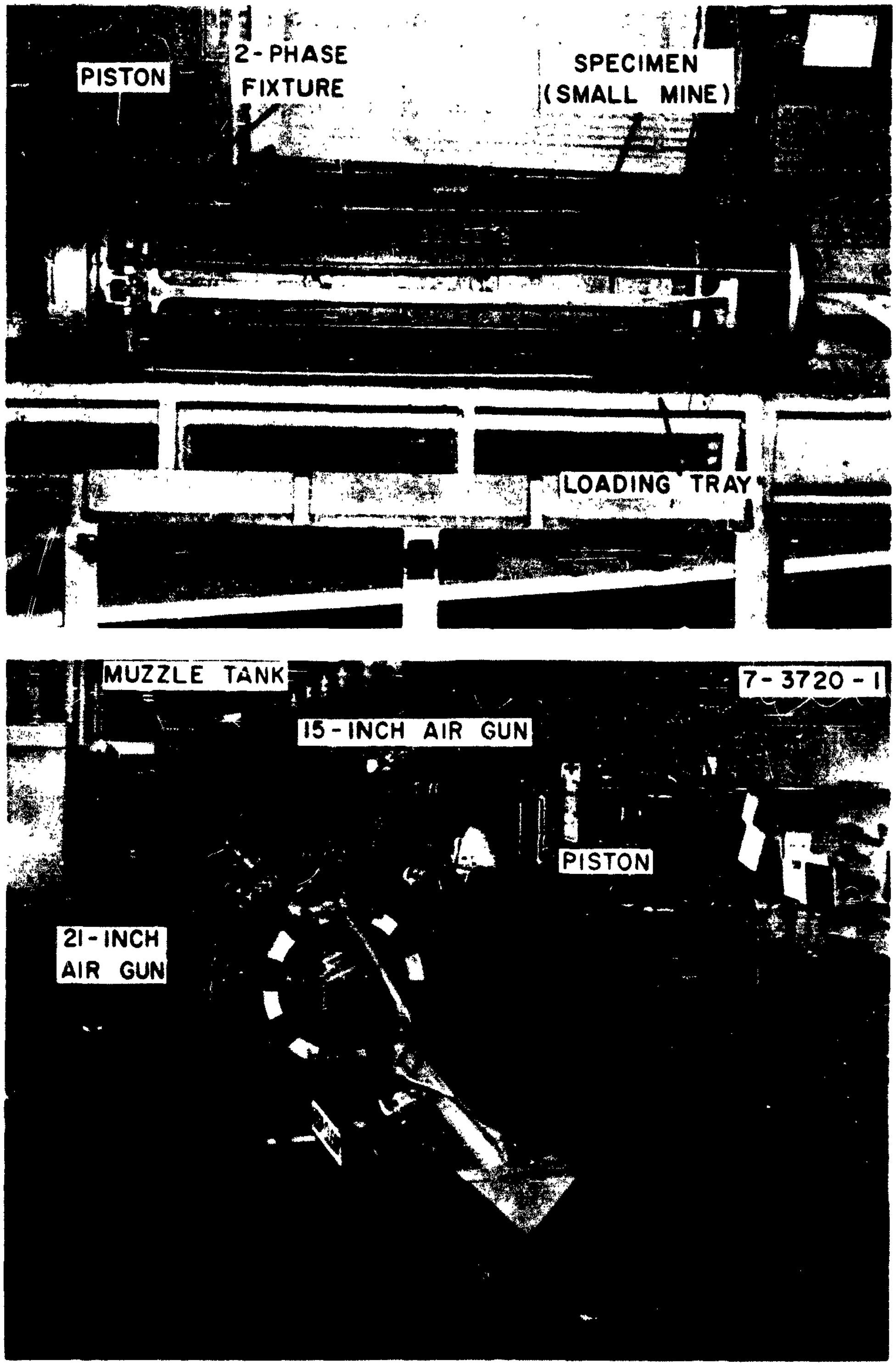

PISTON
2-PHASE
FIXTURE
SPECIMEN
(SMALL MINE)
LOADING TRAY
MUZZLE TANK
7-3720-1
15-INCH AIR GUN
PISTON
21-INCH
AIR GUN

FIG. 9

Fig. 10. NOL 5-in. Air Gun and Piston Assembly

The principal use of this gun is to test projectile fuzes under controlled setback shock. A 5-in./51 Naval gun was modified for this use. The barrel length was increased 63 ft by adding extra strength pipe; a muzzle tank was also provided. High acceleration is obtained by the use of high air pressure. The release mechanism is a circularly notched flange or "diaphragm" which holds the piston back. As the breech pressure is slowly built up the flange ruptures at the notch and the piston is free to accelerate. Generally it is possible to design the flange so that the peak acceleration will be within ±10% of the desired value. The peak value of deceleration is less than 5% of the peak value of acceleration.

FIG. 10

Fig. 11. NOL 2-in. Air Gun and Pistons

This gun is similar to the 5-inch gun and is used to test small projectile fuzes under very high accelerations. The piston is released by the rupture of a notched flange which for this gun, is integral with the piston. Thus, a piston is expended for each shot. The peak acceleration is generally within ±15% of the desired value for acceleration greater than 30,000 g. The accuracy is less for lower acceleration.

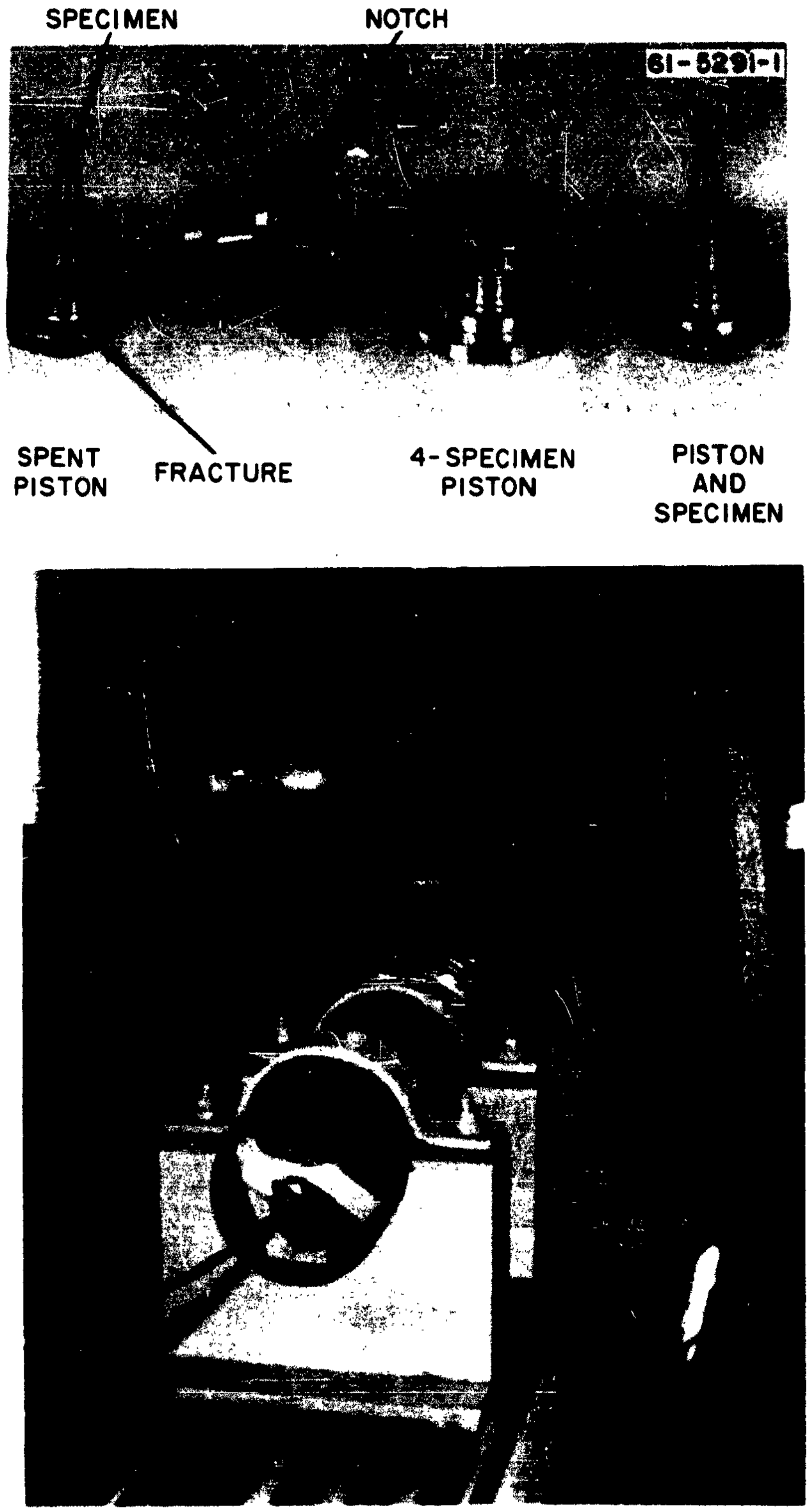

SPECIMEN
NOTCH
61-5291-1
SPENT PISTON
FRACTURE
4-SPECIMEN PISTON
PISTON AND SPECIMEN

FIG. 11

Fig. 12. HYGE Shock Tester Model 6407

This tester produces mechanical shock by the controlled release of compressed gas behind a piston. The piston accelerates an external carriage upon which the specimen is mounted. The shape of the load pulse delivered by the piston is controlled by two metering pins, one for accelerating the piston and the other for bringing it to rest. These may be designed to give well-defined pulse shapes such as sinusoidal, triangular, and square. The carriage is brought to rest by internal brakes which act on the guide rails. A specimen mounted in the HYGE machine is accessible for instrumenting and monitoring.

Piston diameter - 6 in.

Weight of piston, thrust column, and accelerated parts - 50 lb approximately

Max thrust (zero displacement) - 45,000 lb

Weight of carriage - 78 lb approximately

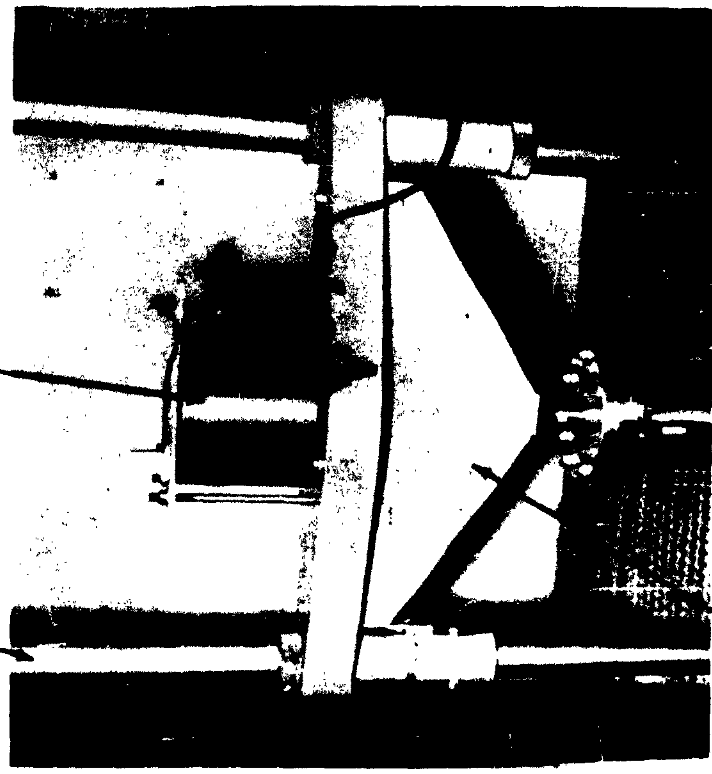
Max piston displacement - 12.25 in.

Rail height - 20 ft

Length between rails - 33 in.

Location - Room 20-028

Manufacturer: Consolidated Vacuum Corporation
Rochester 3, New York


61-6545-3
SPECIMEN
GUIDE RAILS
LOADING CYLINDER
CARRIAGE

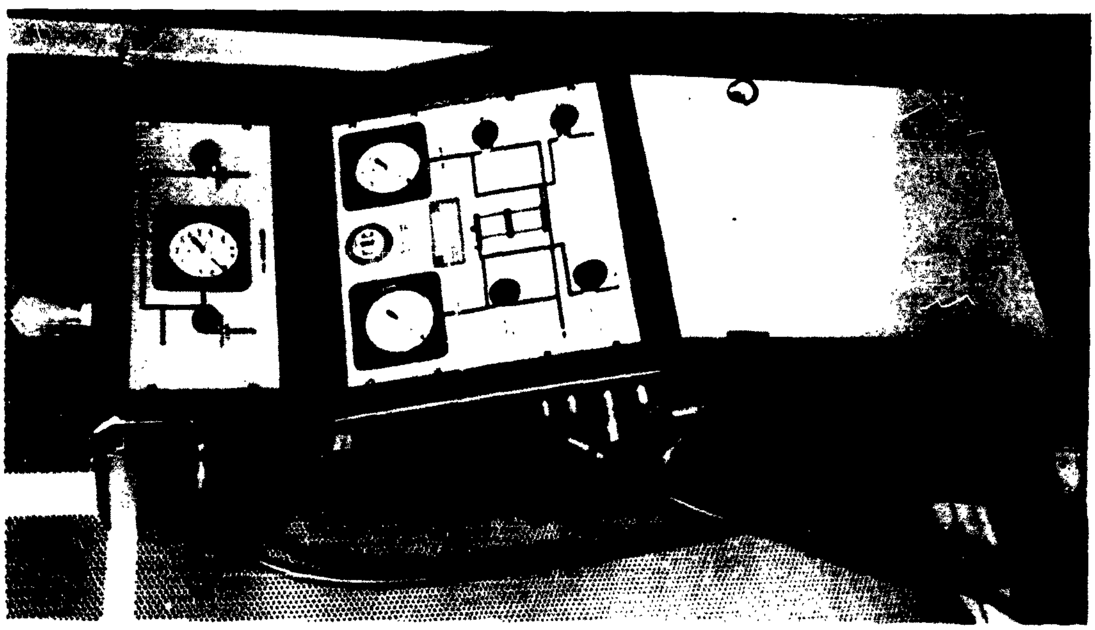

61-6545-2

FIG. 12

LAUNCHERS FOR IMPACT TESTS OF MISSILES

The shock test facilities known as launchers are open-muzzle air guns, the function of which is to accelerate a test missile to the velocity of target or water impact. The purpose of the test is to determine the effect of impact; the acceleration produced in the gun is only incidental to attaining the required velocity. All NOL launchers are similar in principle but have different arrangements of the gun and target. The missile is propelled by compressed air in the breech. The required air pressure is built up behind the piston which is held back by a notched break-link. The gun may be fired upon command by a hammer device which adds an impact load to the static tensile load. The velocity is controlled by varying the air pressure. The instrumentation available for measuring and recording the velocity and acceleration of the missile at impact is approximately the same for all launchers.

Fig. 13. NOL 5-in. Target Impact Launcher (For Hard Targets)

This open muzzle air gun fires a missile against a prepared slab, plate, or structure representing a service target. Target is positioned to obtain desired angle between flight path and target surface.

Barrel - 5-in. bore, 22-ft length

Air pressure, maximum - 1000 psi

Velocity obtainable - 700 fps on 30-lb, 5-in. missile

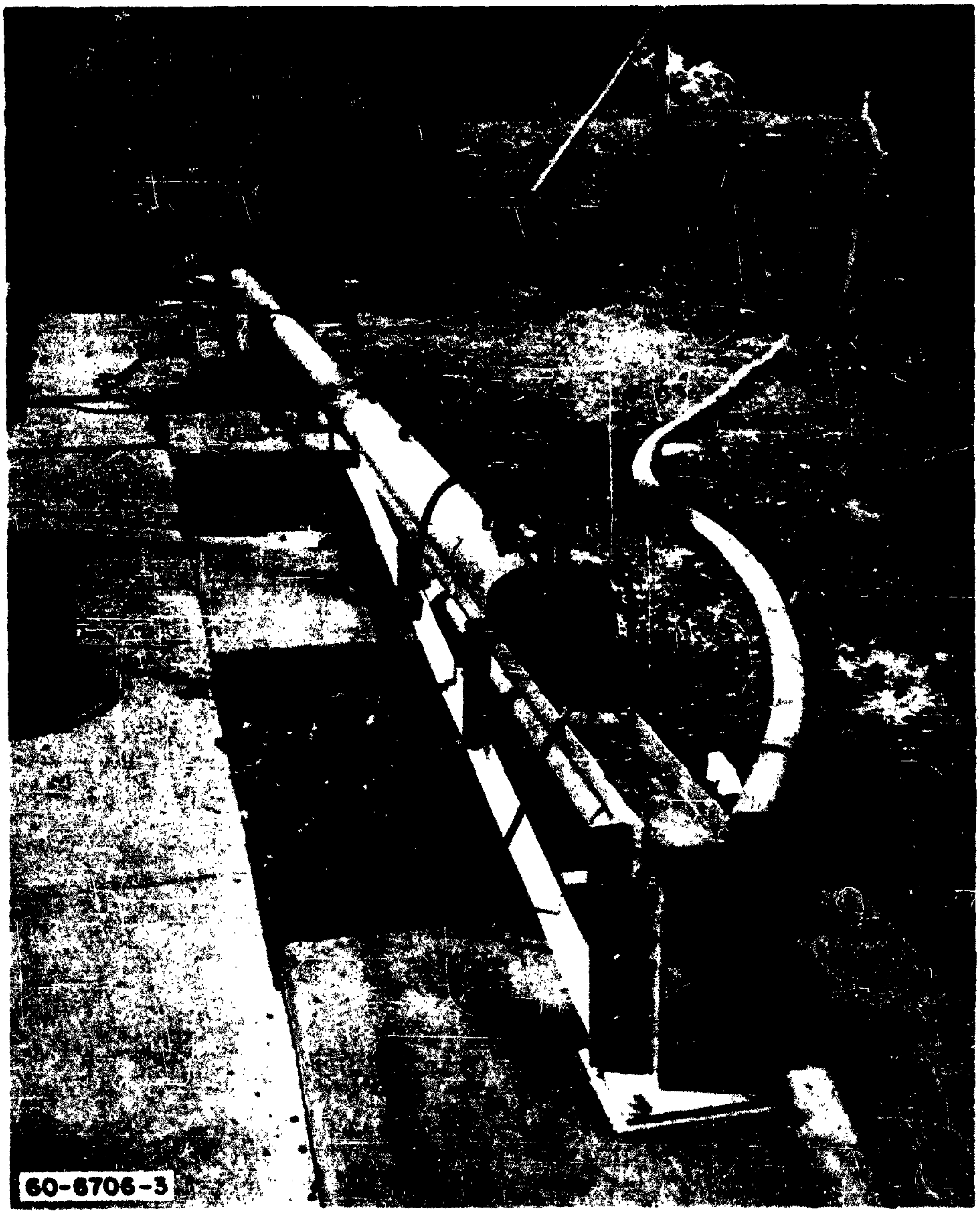


FIG 13

Fig. 14. NOL Test Pond Launcher

This facility consists of an open-muzzle air gun mounted 5° to 90° to the horizontal. The gun is located over a pond so that missiles may be fired into water, or the pond may be drained and a hard target such as a concrete slab may be placed on the ground. High speed motion pictures are usually taken of each shot. The water entry velocity is determined by means of two spaced photomultiplier units in front of the gun. The water entry decelerations experienced by the missile are measured by means of a peak-reading copper-ball accelerometer which discriminates between water entry and bottom impact shocks, or by continuous recording accelerometers with trailing electrical leads. To assist in recovering a missile shot into water a trailing mechanical cable is usually attached to the missile either directly, or by means of a "snare" as the missile leaves the muzzle.

The missile may be full scale within the size and weight limitations; frequently it is a scaled model of a larger missile. A wooden sabot is used to support and drive the missile in the barrel and maintain it in the desired attitude at impact.

Barrels available, dia - 3, 10, 13 1/4 and 14 1/4 in.

Barrel length - 20 feet

Max. weight of specimen - about 500 lb

Max. air pressure - 1000 psi

Max. velocity - 380 ft/sec for 500-lb missile
1050 ft/sec for 50-lb missile

Max. water depth - 10 ft

Firing positions provided, angle from horizontal - 5° steps, 5° to 90°

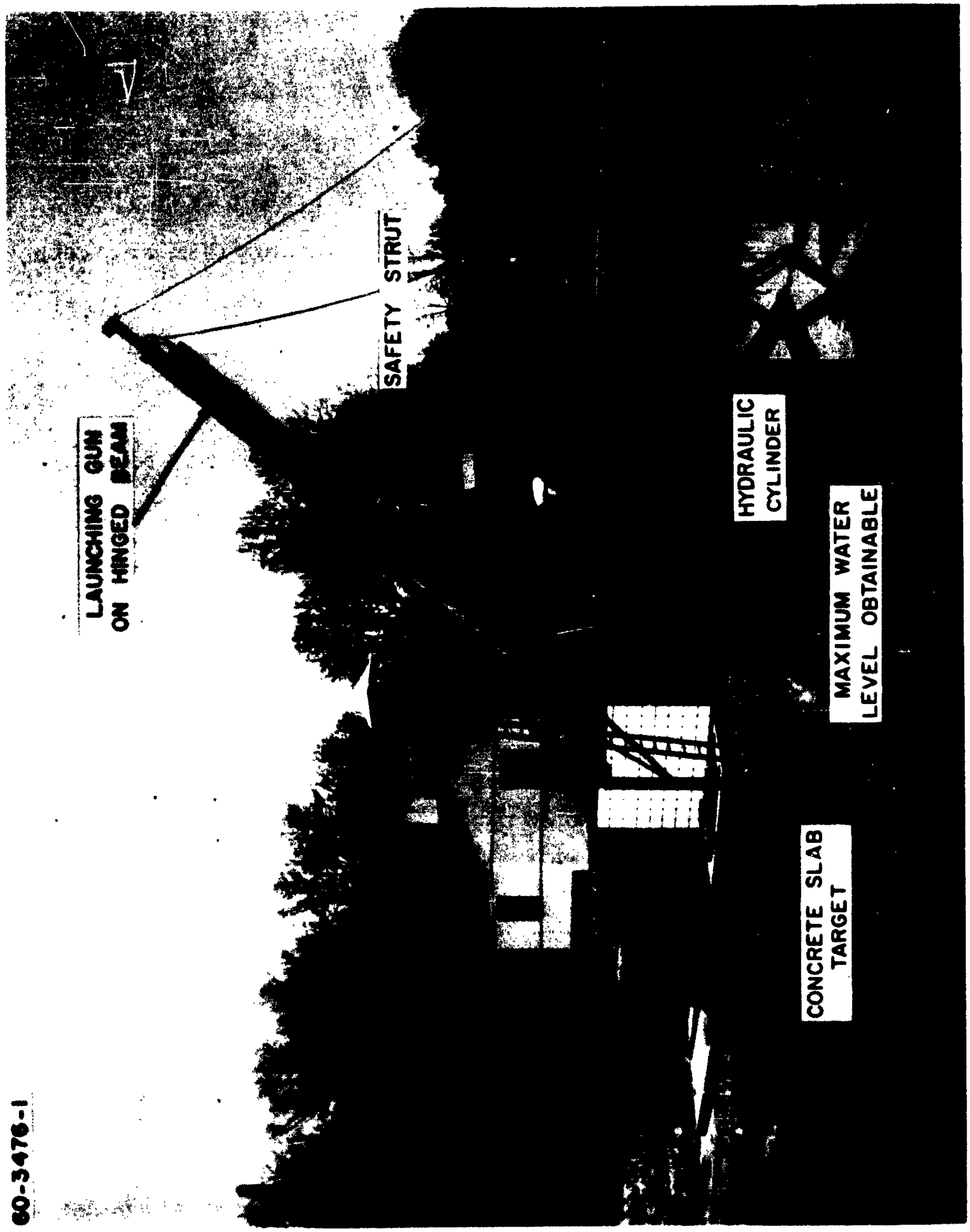

LAUNCHING GUN
ON HINGED BEAM
SAFETY STRUT
HYDRAULIC
CYLINDER
MAXIMUM WATER
LEVEL OBTAINABLE
CONCRETE SLAB
TARGET
60-3476-1

FIG. 14

Fig. 15. NOL 5.6 in. Launcher and Tank

A fixed open-muzzle air gun fires a test missile into the side of a rectangular tank containing water. Variable angle of water entry is obtained by means of a thin frangible plastic diaphragm mounted in the wall. Interchangeable brackets for mounting the diaphragm provide desired angle between flight path and water surface. The missile exits through another diaphragm in the opposite wall and is brought to rest in a container filled with cotton waste. A cage made from steel bars conducts the missile to the exit. The gun is similar in construction to the Test Pond Gun and similar instrumentation is used.

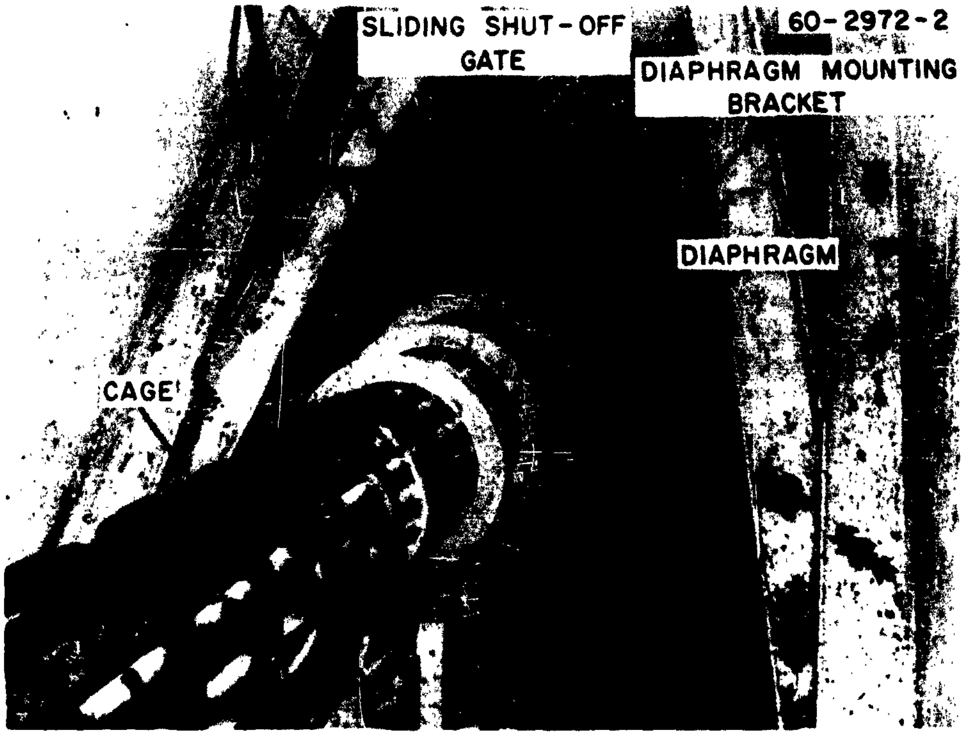
Bore of gun - 5.6 in.

Length of barrel - 38 ft

Maximum air pressure - 3200 psi

Velocity obtainable - 1400 ft/sec on 33-lb missile

Available brackets - 45°, 60°, and 70° angle between flight path and water surface


SLIDING SHUT-OFF GATE
60-2972-2
DIAPHRAGM MOUNTING BRACKET
DIAPHRAGM
CAGE


60-2972-14
GUN
TANK

FIG. 15

DROP TESTERS

Vertical drop resulting in impact is a simple means for producing a controlled shock for test purposes. A drop tester is a machine for performing such a test. The drop test is especially suitable for short-duration pulses, but by cushioning the impact it is possible to obtain quite a variety of pulse shapes. The specimen is accessible for observation and for connecting instrumentation. Repetitive tests of production samples can be made rapidly and cheaply. All drop testers with the exception of the BARRY 20 VI were designed and developed at NOL. All employ vertical gravity drops. An additional accelerating force is applied to the carriage of the Mk 7 Mod 0 to obtain a higher velocity at impact. The characteristics are given in Table 2 and in the descriptions of each facility. All are located in Room 20-026 except the 10-ft drop tester which is in Room 20-067 and the SED testers which are located in the shaft of Elevator 20-1.

Cushioning devices may be used in nearly all drop testers to control the shape of the acceleration-time pulse. Commonly used materials are pads of lead in various shapes, rubber, leather, and polystyrene foam. In general, the shock parameters depend more on the cushioning material than on the individual facility.

Cushion	Range of Peak Acceleration g	Duration Of Pulse ms
None; steel-on steel	200 - 80,000	0.04 - 0.4
Lead Pad	10 - 10,000	0.4 - 25
Highly cushioned; rubber, cork, styro-foam, etc.	2 - 50	5 - 50

Table 2. Characteristics of Drop Testers

Designation	Fig.	Maximum Weight of Specimen lb.	Table Diameter or Dimensions in.	Nature of Impact; Cushioning Material
NOL 10-ft. Drop Tester	16	150	22	Steel-on-steel or cushioned
NOL 12-in. Drop Tester	17	20	8	Steel-on-steel or cushioned
Drop Shock Tester Mk 7 Mod 0	18	25	8	Special sand-filled rubber bag or lead pad
NOL Short Duration Shock Tester	20	2	1.25	Steel-on-steel
BARRY Component Shock Tester Mod 20 VI	21	50	18	Penetration of sand bed or lead block
Test Set Mk 209 Mod 1	22	5	5 x 6	Nylon, rubber, or hard felt
NOL Self-Emplaceable Drop Testers	19			Steel-on-steel or cushioned
SED-100		100	20	
SED-2000		2000	12 x 84	

Fig. 16. NOL 10-ft Drop Tester

This machine provides a guided gravity drop from a height as great as 10 ft. For steel-on-steel impact the maximum drop height is 1 ft; cushions are used for greater heights. A great range of pulse duration and peak value is obtained by varying the drop height and the cushioning.

The carriage is attached to and released from the lifting yoke by a pair of solenoid-actuated release mechanisms. The anvil is mounted on a block of concrete 5 ft deep set in the ground.

Fig. 17. NOL 12-in. Drop Tester

This small, versatile, general-purpose machine consists of a carriage upon which the test specimen is mounted, an anvil weighing 1000 lb, guide rails, hoist, and release mechanism. For heights up to 12 in. the carriage may be dropped directly on the anvil for steel-on-steel impact. Cushions are used for drop heights up to 24 in.

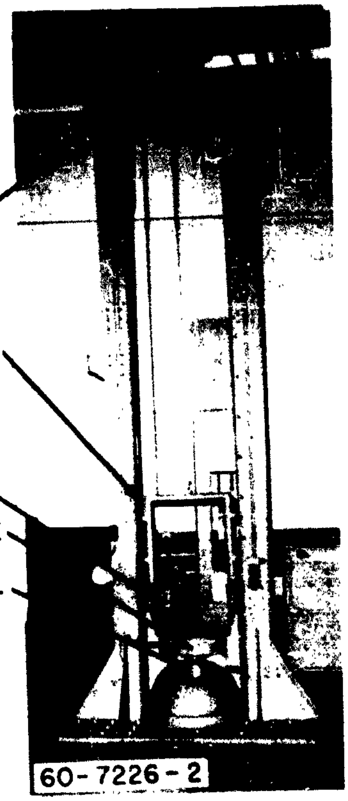

HOIST
LIFTING YOKE
SOLENOID CARRIAGE RELEASES
CARRIAGE
ANVIL
60-7226-2

FIG. 16

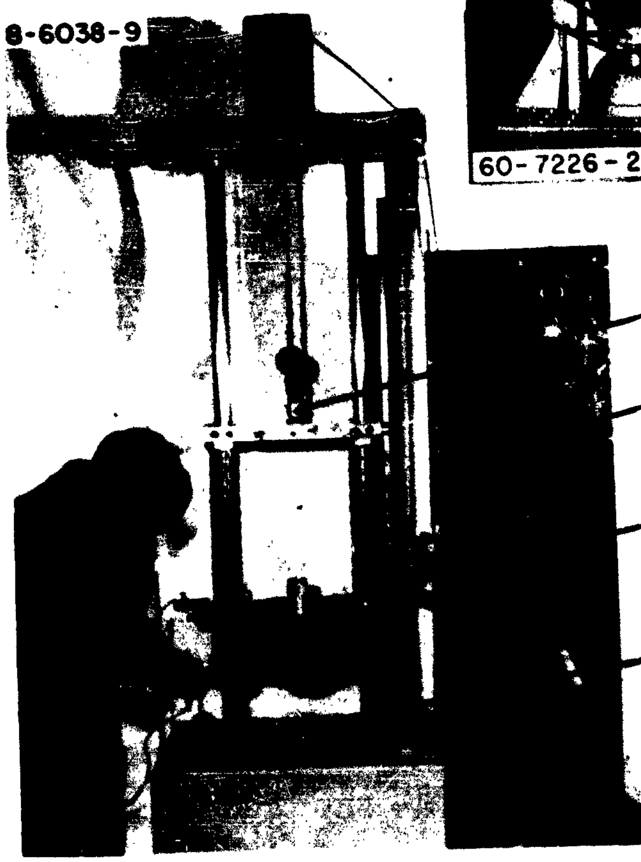

8-6038-9
MANUAL RELEASE
CARRIAGE HOIST AND BRAKE
CARRIAGE
ANVIL

FIG. 17

Fig. 18. Drop Shock Tester Mk 7 Mod 0

This is a portable machine developed for production testing of mine and depth charge components. Elastic cords are employed to accelerate the carriage during the drop to a velocity as great as that resulting from a free fall of 100 ft. A variety of stopping devices may be used between the carriage and anvil to control the shape of the shock pulse. Sand-filled rubber bags have been developed for this machine. Experience has shown that the results are predictable and reproducible and the bag may be reused hundreds of times. Lead pads of various shapes are also used. The machine is portable, and because the anvil is seismically mounted, no special foundation or floor is required. The elastic cord is contained inside the tubular columns of the machine. A hoist is provided for raising the carriage and elongating the cord. The characteristics of the machine are as follows:

Floor space - 2 1/2 x 6 ft.
Height - 11 ft.
Weight - 2500 lb.
Max. pulse amplitude - 800 g
Pulse duration - 5-25 ms
Test specimen space - 8 in. dia. by 8 in. high
Test load at max. shock - 10 lb.
Max. test load - 25 lb.
Max. velocity change - 80 fps
Natural frequency of carriage - about 1200 cps
Max. available energy - 3300 ft-lb.
Carriage propulsion system - 5/8-in. elastic shock cord and 3/16-in. wire rope tow cable
Publications - NAVORD Report 4386
NAVORD OCD 1362401
NOL Reprint of paper: "A Portable 100-ft. Drop Tester" by J. C. New from Shock and Vibration Bulletin No. 20, May 1953

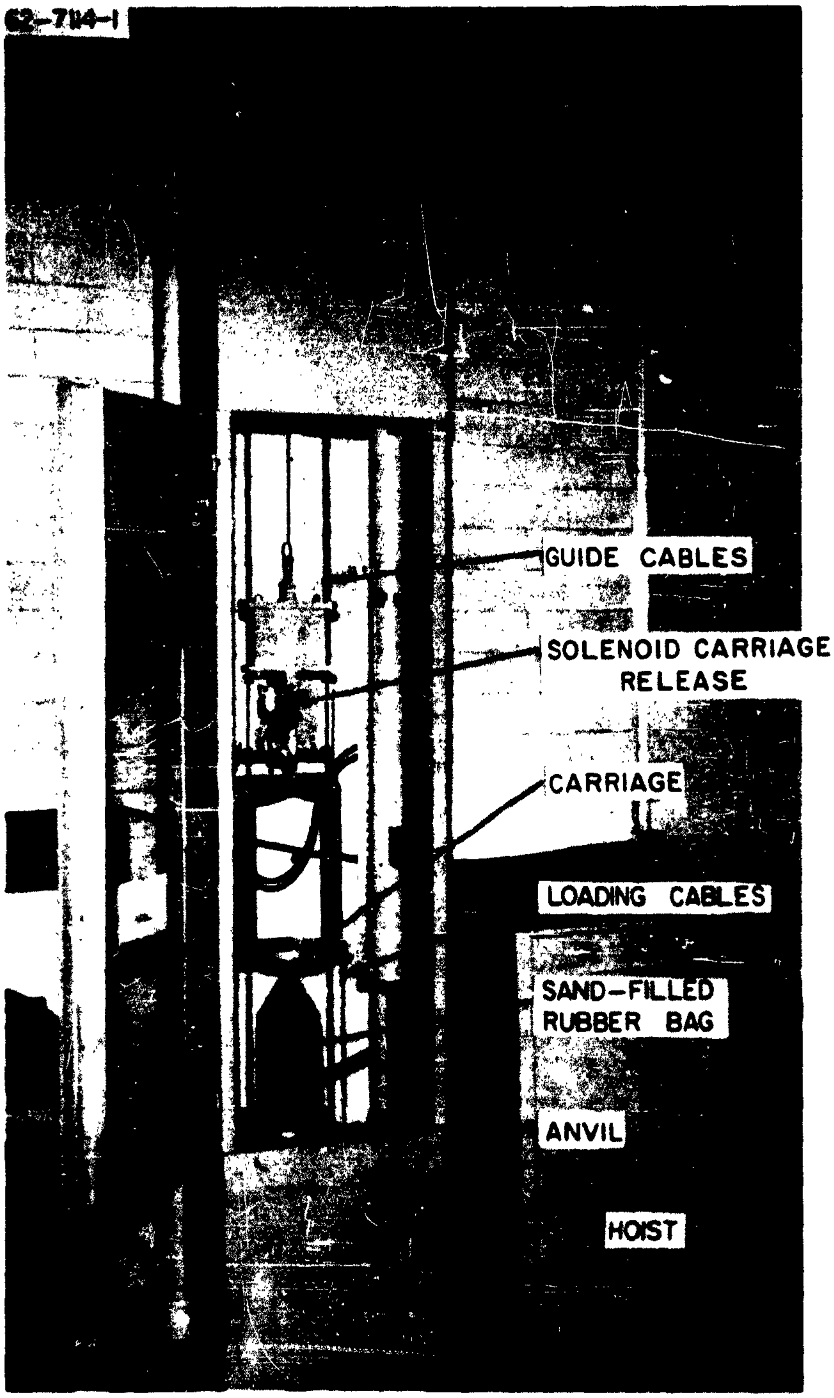

62-7114-1
GUIDE CABLES
SOLENOID CARRIAGE RELEASE
CARRIAGE
LOADING CABLES
SAND-FILLED RUBBER BAG
ANVIL
HOIST

FIG. 18

Fig. 19. NOL Self-Emplaceable Drop (SED) Tester

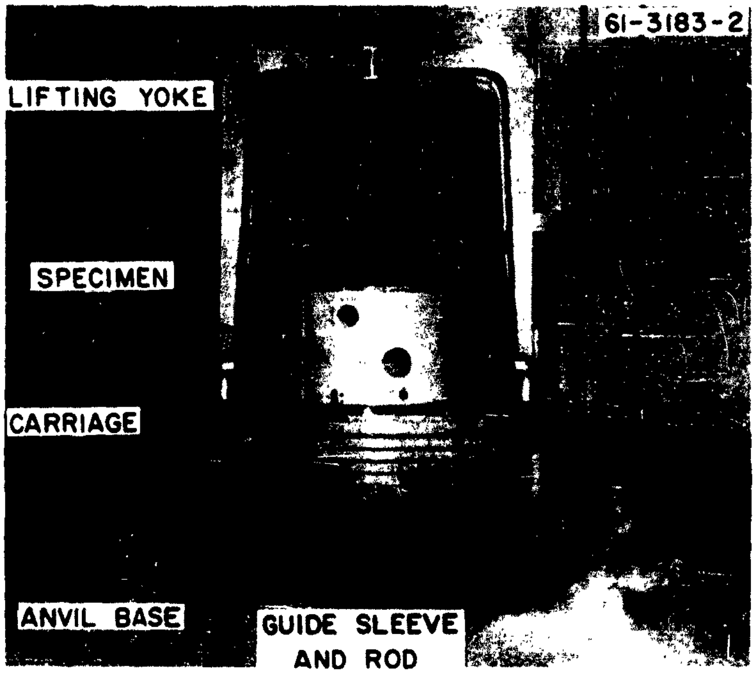
An innovation in drop testers is the SED Tester recently developed by the Environment Simulation Division, NOL. The Tester consists of a carriage upon which the specimen is mounted and a heavy base with anvil initially separated from the carriage by a few inches. Carriage and anvil are mutually guided to remain parallel and free to move relative to each other until collision with each other occurs. The whole assembly is raised by a hoist and allowed to drop freely at a level attitude into a bed of sand. The base emplaces itself in the sand under its own inertia. A few milliseconds later the carriage collides with the anvil producing shock.

The magnitude and duration of the acceleration pulse depends on the drop height, the separation between carriage and anvil, and the cushion. As in other drop testers, a great variety of cushions may be used and the characteristics of the acceleration pulse may be varied considerably. The facility is especially useful in simulating shipboard shock caused by nearby underwater explosion. Similar stresses and mechanical effects have been produced in Naval weapons as were found in actual field tests. Among the desirable features of the SED Tester are elimination of massive base and columns, unrestricted drop height, adaptability to large and long specimens, adaptability to tests of specimens containing explosives, portability, simplicity, and low cost.

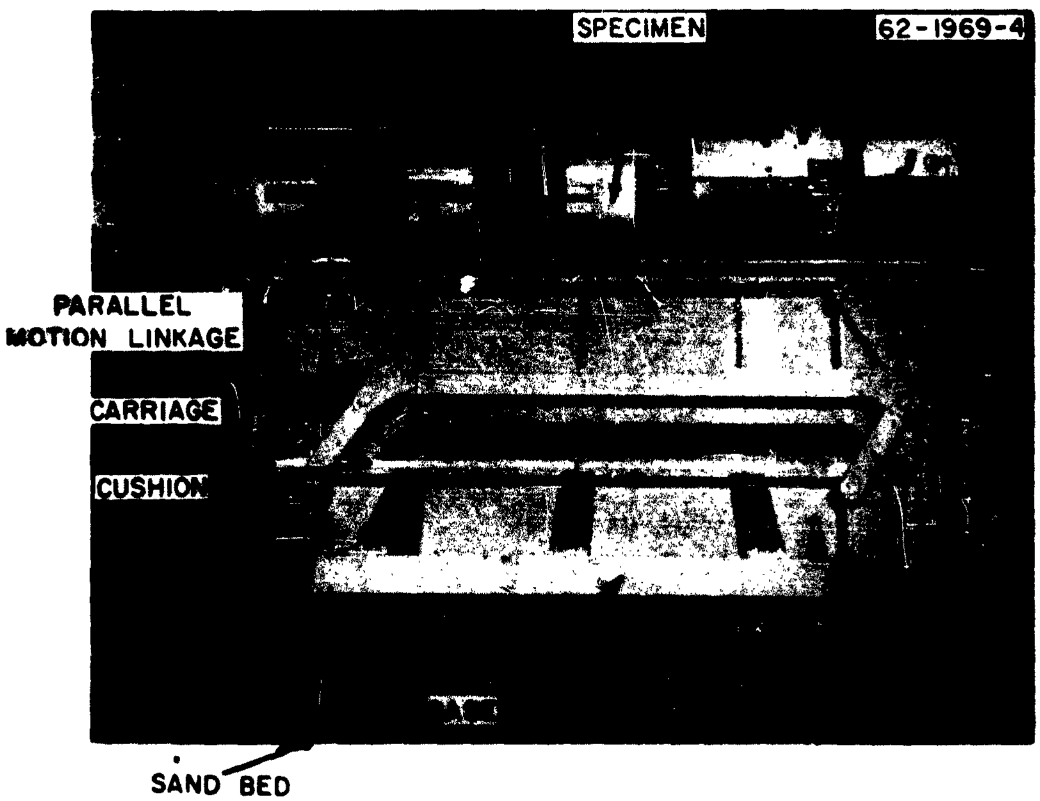
Tests are performed in the elevator shaft No. 1 of Building 20 and the elevator hoist and car are available to raise the assembly for the drop. The sand is contained in a steel enclosure 8.7 ft in diameter by 3 ft deep mounted on leaf springs. The sand bed is thus a seismic platform.

Two models of the tester have been built. The following characteristics are given in addition to those in Table 2:

	SED 100	SED 2000
Max. drop height, ft	40	10
Max. velocity change, ft/sec	50	16
Max. amplitude of acceleration, pulse, uncushioned, g	10,000	5000
Duration of acceleration pulse, uncushioned, ms	0.1-0.3	0.1-0.3
Max. amplitude of acceleration pulse for shipboard shock test, (slight cushioning), g	3000	1500



SED
TESTER
100



SED
TESTER
2000

FIG. 19

	SED 100	SED 2000
Duration of pulse for shipboard shock test (slight cushioning), ms	1-3	1-3
Max. separation between carriage and anvil, in.	12	12
Weight of carriage, lb	140	1000
Weight of base	910	6500

Fig. 20. NOL Short Duration Drop Tester

An acceleration pulse high in peak value but of extremely short duration is obtainable with this machine. It is often used for calibrations of high-natural-frequency crystal accelerometers. The bottom surface of the carriage is curved to a radius of 50 in., thus, impact duration is extremely short. The carriage is guided by taut piano wires which pass through it; the wires are tensioned by weights inside the base. The maximum height of drop is 12 in.

An acceleration pulse as high as 50,000 g in amplitude with a duration of about 0.05 ms is obtainable with this facility.

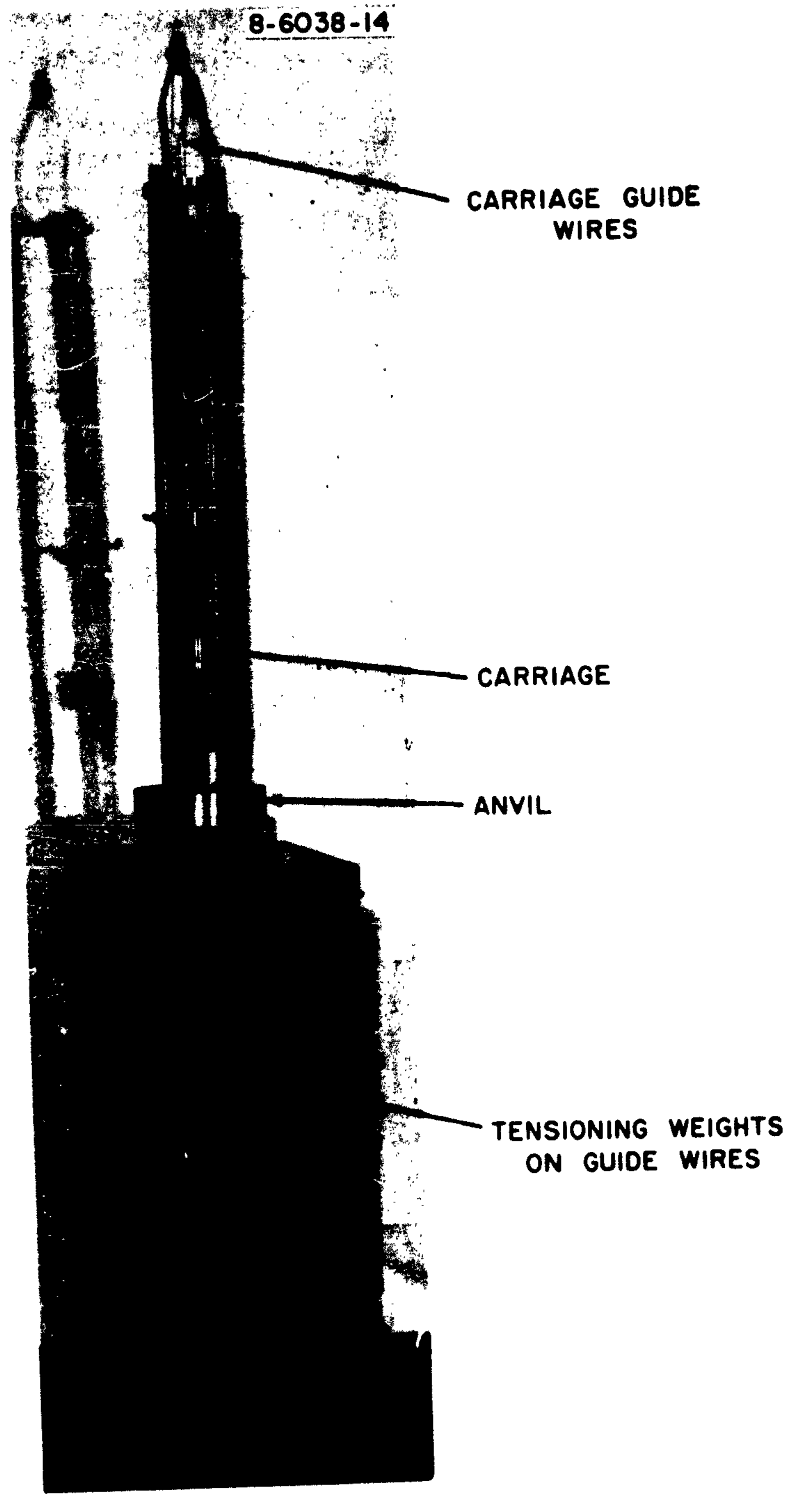

8-6038-14
CARRIAGE GUIDE WIRES
CARRIAGE
ANVIL
TENSIONING WEIGHTS ON GUIDE WIRES

FIG. 20

Fig. 21. BARRY Component Shock Tester Model 20 VI

This commercial drop tester produces a guided gravity drop up to 5 ft. Two methods of cushioning are used. In one, wooden blocks attached to the bottom of the carriage penetrate a bed of sand in the base of the machine. Different arrangements of the blocks permit variation in the characteristics of the resulting shock. In the other, a punch attached to the bottom of the carriage is driven into a block of lead. Punches of different diameters are furnished. An acceleration amplitude as great as about 200 g is obtainable.

Fig. 22. Test Set Mk 209 Mod 1

This small, portable, free-fall drop tester is used for specification and design tests of ordnance weighing up to 4 lb. Improvements in the Mk 209 Mod 0 Tester (NAVWEPS OD 20944) are incorporated in the Mod 1, with increased range, performance, and accuracy. Mod 1 parts are interchangeable with those of Mod 0. The solid nylon carriage is highly resilient and rebounds more than 50 per cent of the drop height. The maximum drop height is 70 in. The softest cushion produces shocks up to 170 g peak with a pulse duration of 12 ms; the hardest produces shocks up to 3200 g peak with a duration of 0.6 ms. The maximum impact velocity change experienced by the carriage is 35 fps. The Tester has been used to calibrate shock transducers and to test the sensitivity of inertially-actuated devices.

Publication: NOLTR 61-106

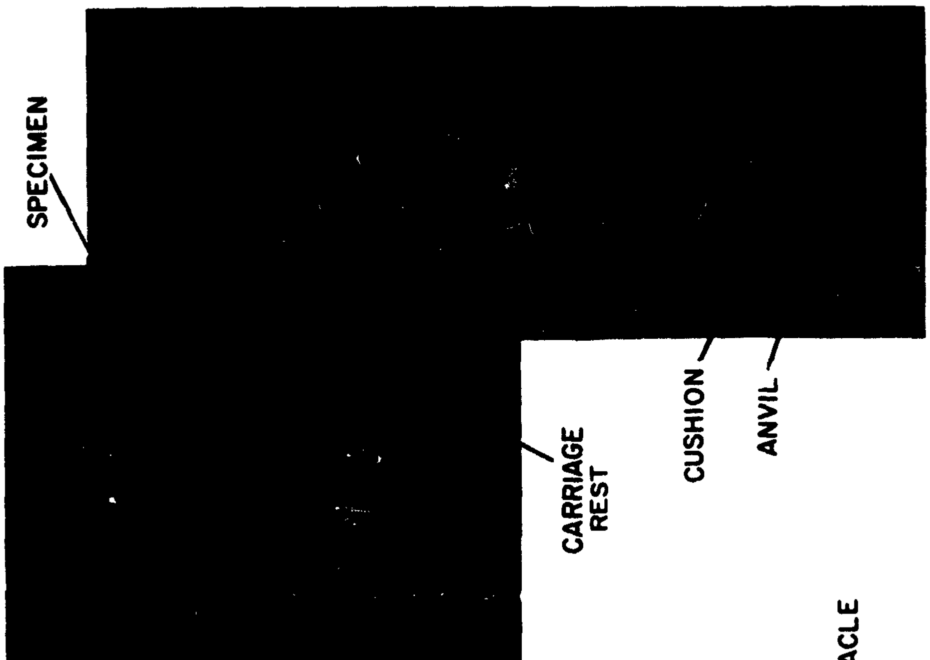

62-3894-1
SPECIMEN
CARRIAGE REST
CUSHION
ANVIL
NYLON CARRIAGE

FIG. 22

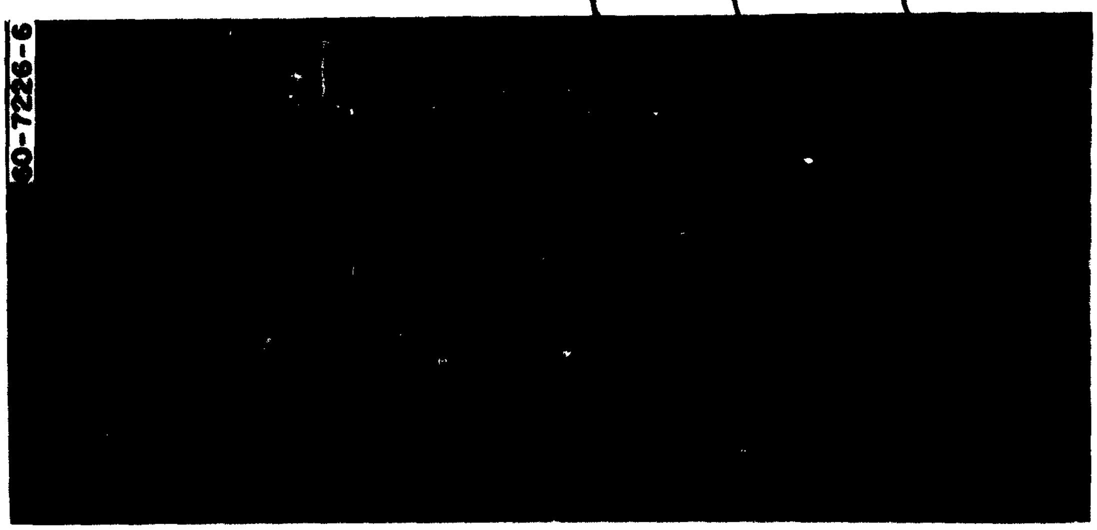

60-7226-6
CARRIAGE RELEASE
CARRIAGE
SAND RECEPTACLE

FIG. 21

Chapter 4

ACCELERATION

The type of acceleration environment discussed in this chapter is characterized by slow buildup, relatively gradual variation and long duration as in missile boost and re-entry. The centrifuge is the most practicable laboratory means for producing such acceleration.

CENTRIFUGES

In general, a centrifuge used for this purpose consists of an arm which rotates about a fixed vertical axis and has provision for mounting the specimen at one end. The arm is usually counterbalanced. The length of the arm must be scaled to the size of the specimen so that the gradient of acceleration across the specimen will not be excessive. The characteristics of the centrifuges in the Environment Simulation Division are given in Table 3. All are equipped with slip rings for instrumentation and communication with the specimen.

Table 3. Characteristics of Centrifuges

Designation*	Fig.	Type	Maximum Load at 100 g lb	Max. Size of Specimen Approx., in.	Max Speed rpm	Slip Rings
NOL 10-ft	23	Single arm, various radii, 10 ft max.	50	2-ft cube	600	50 5-amp, 9 50-amp unshielded; compressed air
NOL 5-ft	24	Double arm	50	1-ft cube	250	Same as 10-ft.
GENISCO D-184	25	Horizontal disk 24 in. dia rotating about center.	10	8" vertical clearance	1650	8 1-amp shielded 8 5-amp unshielded
NOL 18-in.	26	Double arm	25 at 70 g	6 x 6 x 10	390	6 5-amp
International	27	Double arm 11-in. rad.	10	5-in. cube	3000	6 5-amp

*NOL Centrifuges are designated by the maximum radius of rotation of a specimen mounted on the arm.

Fig. 23. NOL 10-ft Centrifuge

This machine is a conventional centrifuge and has several interchangeable arms, up to about 10 ft in radius. The arms are not counterbalanced. The central bearing and foundation structure are strong enough to stand the centrifugal force of arm and load. The arm is driven by a 15-hp dc motor through sprockets and chain. The speed is controlled manually by varying the armature voltage and the field current.

Originally, the 10-ft arm, bearing, and foundation were part of the NOL Rotary Accelerator (see NAVORD 3692), a quick-acting centrifuge providing rectilinear acceleration of the test specimen during buildup time.

The arm speed may be varied at a sufficiently high rate to simulate actual boost and re-entry acceleration pulses.

The test specimen is usually bolted to a flange on the end of the arm or to a horizontal base on top.

Provision has been made for combining certain other accelerations with the centripetal acceleration. Fixtures have been tailor-made to produce effects experienced by a component of a particular missile. For example, vibration is introduced by means of a pneumatic hammer device mounted on a base attached to the specimen mounting base. This device excites at two or three frequencies simultaneously and offers very limited control over amplitude and frequency. A crank mechanism powered by an air motor has been employed to introduce a cyclic yawing motion transverse to the axis of the arm. A special hinged arm with a turntable has been used to rotate the specimen about its own axis while it experiences acceleration transverse to its own axis. The purpose of the hinge is to meet a special requirement for quickly changing the orientation of the specimen.

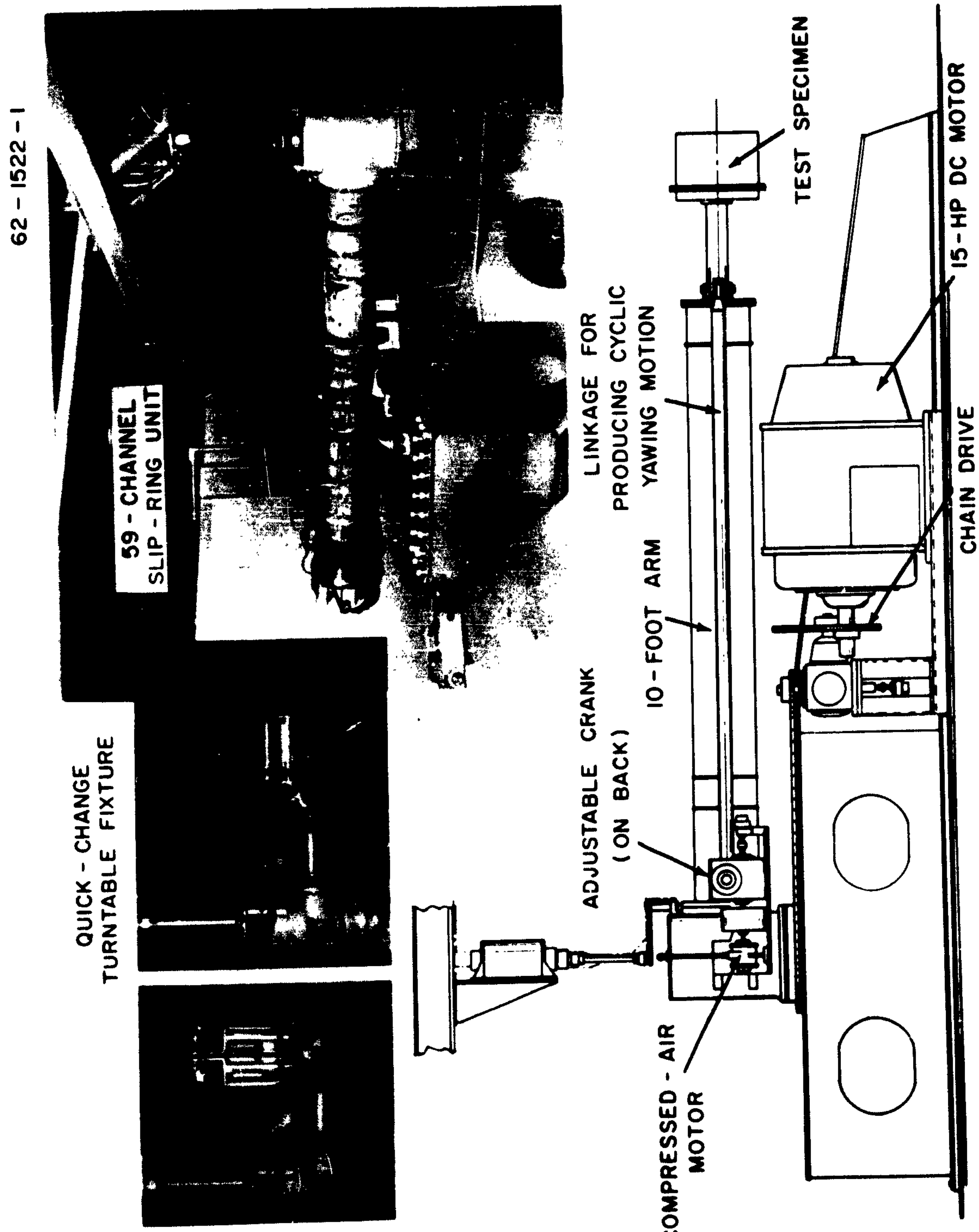

62 - 1522 - 1
59 - CHANNEL
SLIP - RING UNIT
QUICK - CHANGE
TURNTABLE FIXTURE
TEST SPECIMEN
15 - HP DC MOTOR
LINKAGE FOR
PRODUCING CYCLIC
YAWING MOTION
CHAIN DRIVE
10 - FOOT ARM
ADJUSTABLE CRANK
(ON BACK)
COMPRESSED - AIR
MOTOR

FIG. 23

Fig. 24. NOL 5-ft. Centrifuge

This balanced-arm machine has arrangements for adjusting the counterbalance in place and positioning the mounting base vertically so that the c.g. of the base and specimen lies on the axis of the arm. The machine is located within a circular safety enclosure made from 1/4-in. and 3/8-in. steel plate. The arm is driven by a hydraulic motor through a toothed belt. A DENISON variable delivery hydraulic pump unit supplies the motor. The machine has sufficient capability of speeding up and braking the arm to simulate missile boost and reentry. Braking is accomplished by applying hydraulic pressure to the outlet of the motor. This back pressure is controlled by an electrohydraulic relief valve.

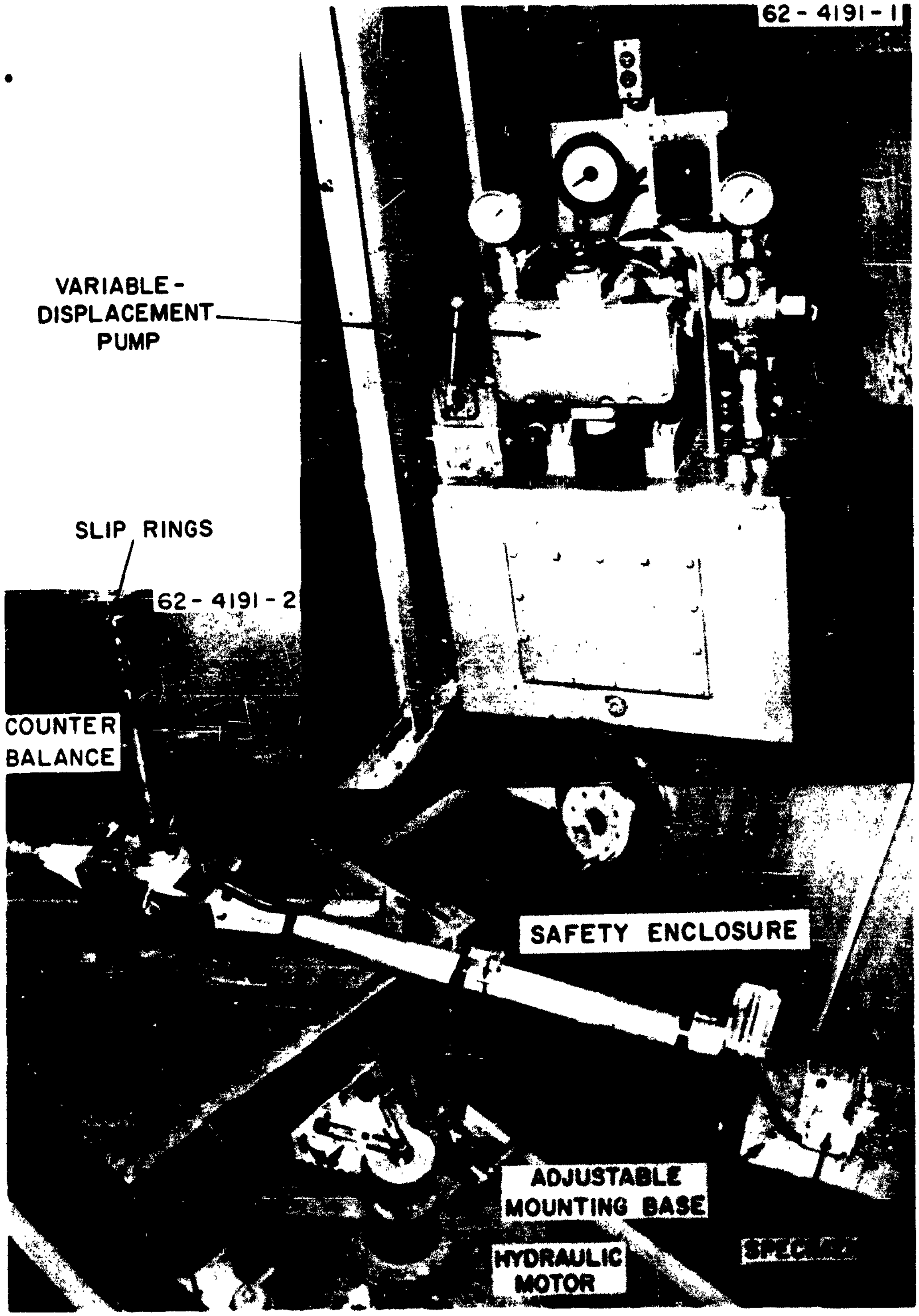

62 - 4191 - 1
VARIABLE-
DISPLACEMENT
PUMP
SLIP RINGS
62 - 4191 - 2
COUNTER
BALANCE
SAFETY ENCLOSURE
ADJUSTABLE
MOUNTING BASE
HYDRAULIC
MOTOR

FIG. 24

FIG. 25 GENISCO MODEL D-184 CENTRIFUGE

8-6038-7

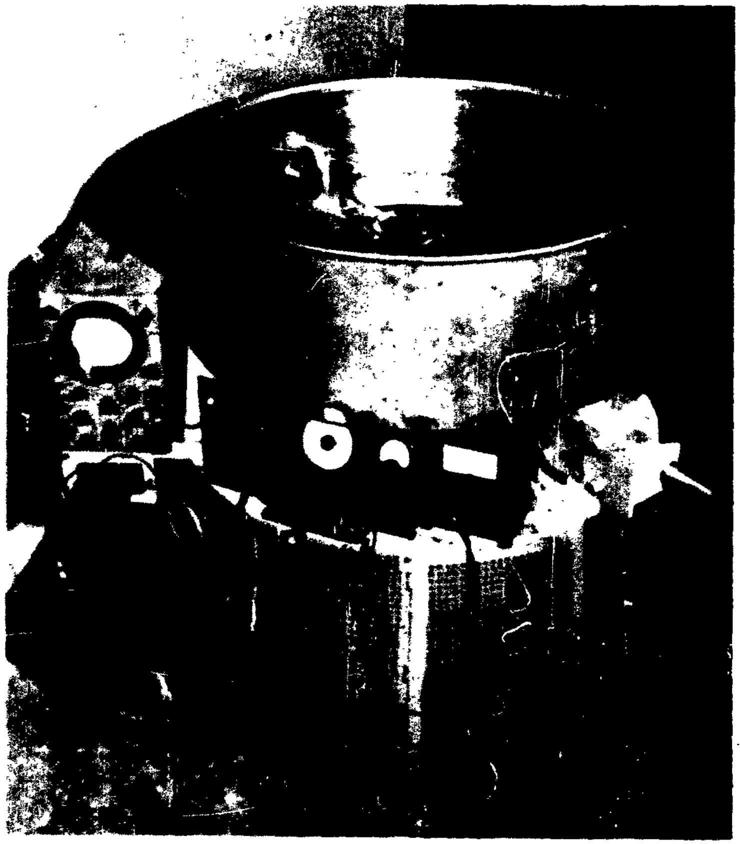


FIG. 26 NOL 18-IN. CENTRIFUGE

8-6030-3

FIG. 27 ADAPTION OF INTERNATIONAL MATERIALS PROCESSING CENTRIFUGE

Chapter 5

VIBRATION

The function of the vibration machines in the Laboratory is to excite vibration in test specimens of ordnance to determine the performance, endurance, or response under transportation and service vibration. The machines are of two classes, the mechanical reaction type and the electrodynamic.

MECHANICAL VIBRATORS

NOL mechanical vibrators are of the reaction type and employ one or two rotating eccentrics carried on shafts between bearings. These are attached to the bottom of a spring-supported table; the specimen is mounted on the top. The reaction of the centrifugal force generated in the rotors acts on the table and excites it to vibration. The frequency is varied by controlling the speed of the motor driving the eccentric shafts. The mass eccentricity of the rotors may be varied while the machine is running, thus, the amplitude may be varied. The frequency range of the reaction vibrators is about 10-60 cps. They are used extensively for endurance and accelerated service specification tests for transportation and shipboard vibration. NOL reaction machines are equipped with relatively large and substantial tables. The High Capacity Vibrator (HCV-1) can accommodate two large mines at once. Characteristics of the mechanical vibrators are given in Table 4.

In those reaction vibrators in which there is one eccentric or rotor it is of the adjustable mechanical type. This type was developed at NOL and the design is disclosed in U.S. Patent 2,725,745. Where two rotors are used they are of the mercury type and the mass eccentricity is controlled by air pressure. This type also was developed at NOL and the design is disclosed in U. S. Patent 2,703,490. Two-rotor machines give approximately straight line displacement perpendicular to the table because the components of the reaction force parallel to the table cancel each other. The table motion of single-rotor reaction machines deviates from a straight line and may approximate an ellipse or even a figure 8. A rocking mode is present causing greater amplitude at the edge than at the middle of the table. Such deviation from straight line translational motion is tolerated for most routine tests because of the simplicity and reliability of the machine and the advantages of a large table. The

Table 4. Characteristics and Performance of NOL Mechanical Reaction Vibrators

Vibrator Designation	No. Rotors	Frequency Range cps	Max. Peak Force Output[1] lb	Rated Table Load Cap'y lb	Table Size in.	Max. Displacement pk/pk in.	Power
1B	1	10-60	20,000	2000	60 x 60	.12	10-hp dc motor
1A	1	10-75	2000	100	21 x 21	0.12	1-hp SPEED-RANGER
5A (MULTIGEE)	2	7-70	2900	60	15 x 15	.4	3-hp SPEED-RANGER
6A (CTV)	2	7-70	15,000	2000	33 x 40	.3	7.5-hp dc Motor
HCV-1	2	7-70	50,000	6000	60 x 72	.18	30-hp dc Motor
Mechanical Oscillator	2	10-70	15,000	-	-	-	2 4.4-hp hydraulic motors

[1] At a frequency near the maximum

nominal direction of the vibration of all NOL mechanical vibrators is vertical except that the Mechanical Oscillator is adaptable to vibration in any direction, vertical to horizontal. NOL mechanical vibrators have tapped holes in the table, size 1/2 in.-13 in a grid pattern with 4 in. spacing in both directions. Exceptions are vibrators 1A and 5A which have 3/8"-16 tapped holes space 2 in. All the mechanical vibrators are located in Room 20-167.

Fig. 28. NOL Vibrator Type 1B

This is one of the first large mechanical reaction vibrators to be installed in the Vibration Laboratory. The machine was designed and constructed by NOL in 1946. The ruggedness and reliability of this machine are evidenced by its continued 24-hours-per-day operation under endurance tests of ordnance with minimum repair and servicing. The mass eccentricity of the single rotor is adjustable by means of a knob at the edge of the table. The frequency is controlled by varying the speed of the dc drive motor.

Fig. 29 NOL Vibrators 1A (left) and 5A (the MULTIGEE, right) with Portable Temperature Chambers

These are small reaction-type vibrators. Type 1A has a single rotor and is similar in construction to type 1B. Type 5A is the first of the reaction vibrators employing the mercury type rotors developed at NOL. Two flexure plates constrain the table to move in a straight line.

Many vibration tests are performed under specifications which require that the specimen be maintained at a temperature below and above ambient, usually -65°F and 160°F respectively. For large specimens the Controlled Temperature Vibrator is moved into the Walk-in Temperature Chamber. Several portable temperature chambers are used for small specimens. These may be suspended or supported over the table of the vibrator. The chamber temperature may be maintained at any value within the range -65°F to 180°F. Dry ice and electric heaters are used to obtain low and high temperatures respectively. Circulating fans keep the temperature uniform in the chamber. The chamber is attached to the table through a flexible bellows which seals the chamber to the table but does not transmit vibration to the chamber. In general, each chamber may be used on several vibrators. The inside dimensions of the largest chamber are about 2 x 2 x 2 ft. Construction of new chambers employing liquid CO_2 as the cooling medium is in progress.

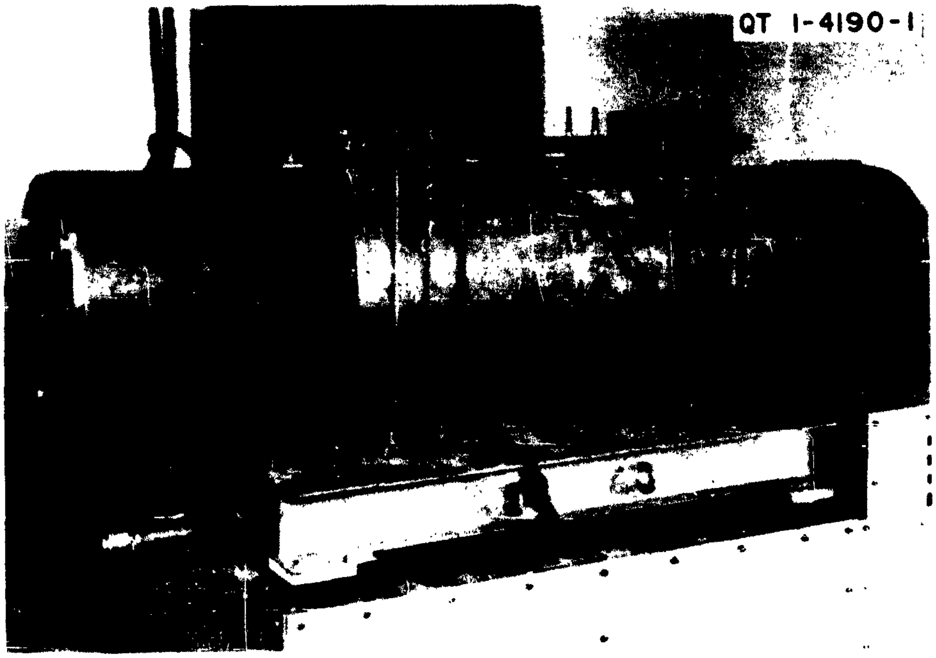


FIG. 28

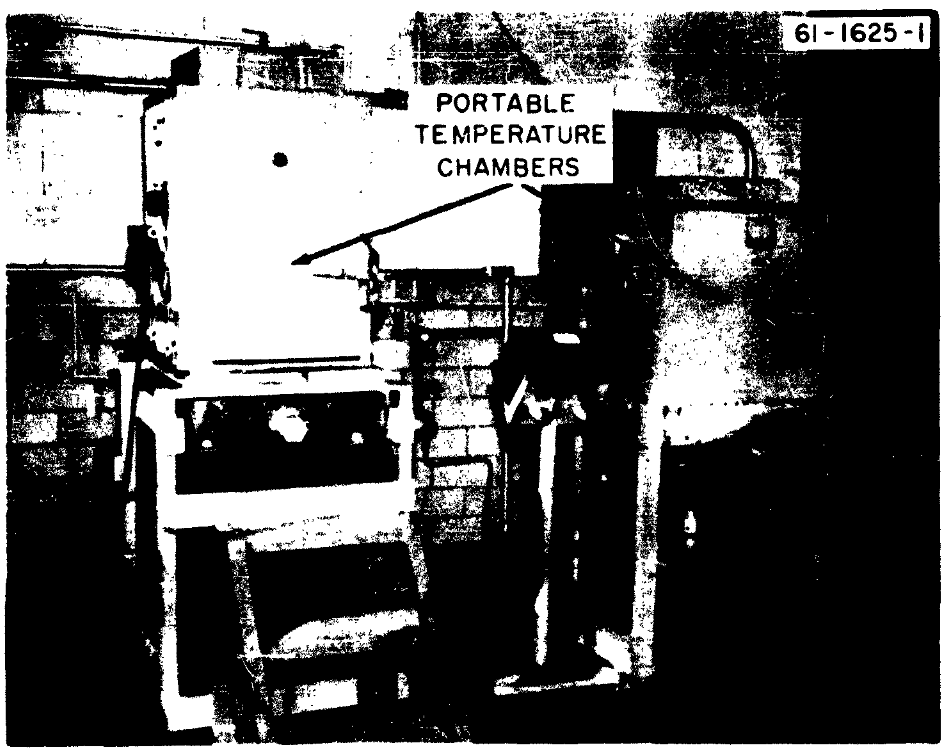


FIG. 29

Fig. 30. NOL Controlled Temperature Vibrator

This mechanical reaction vibrator is equipped to operate inside the Walk-in Temperature Chamber, Figure 3, at temperatures within the range -65°F to 180°F. It has two mercury type rotors and is controlled from outside the chamber. The table capacity, force output, and chamber space are sufficient to permit tests of large mines. Demountable casters facilitate moving the vibrator in and out of the chamber. The machinery compartment is insulated and room air is circulated through it to avoid extremes of temperature.

Publication: NAVORD Report 4310

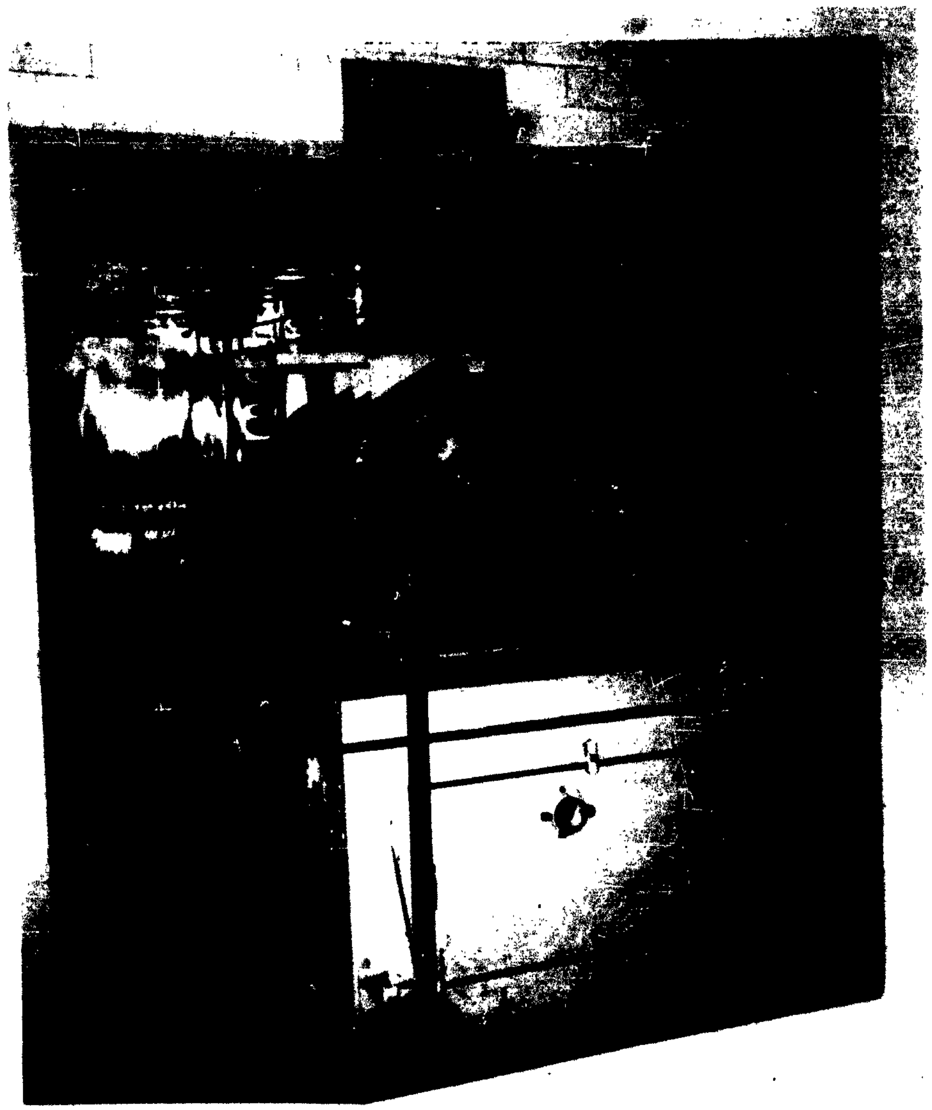


FIG. 30

Fig. 31. NOL High Capacity Vibrator Mod 1

The principal features of the largest reaction machine in the Laboratory are the large table and the high available force output. Endurance and accelerated service tests have been performed on many large weapons since the machine was placed in operation in 1951. Two large mines can be accommodated on the table. The reliability and performance have been continuously improved by development and refinement of some of the principal components.

FIG. 31

Fig. 32. NOL Mechanical Oscillator

This device is a portable vibration exciter of the mechanical reaction type. It is used where the conventional table type vibrators are not suitable, for example, on a structure or large specimen that cannot be brought into the vibration laboratory, where a long specimen must be vibrated in the horizontal axial direction, or under remote control at a suitable site, when the specimen contains explosives.

The facility consists of two units, a steel box containing a pair of mercury type rotating eccentric masses, and a portable hydraulic power unit which supplies two small hydraulic motors on the eccentrics. The box unit weighs 305 lb. The two eccentrics are of the same size used in the NOL Controlled Temperature Vibrator. Lubricating oil is applied under pressure through a hose to the ball bearings of the rotors and returned to the pump in the power unit by means of a scavenging pump. The frequency is controlled by adjusting the variable delivery hydraulic pump which supplies the motors. The box unit is usually connected to the specimen by means of special fixtures constructed for each application. Usually the weight of the box unit is supported from above for horizontal vibration. The direction of the output force is perpendicular to the mounting surfaces. The output force may be oriented in any direction by positioning the box, but the rotor axis must remain horizontal. The available output force increases rapidly with the frequency but for sustained operation is limited by the heating of the bearings at high frequency. The characteristics of this machine are as follows:

Frequency range - 10-70 cps

Maximum force output - 1100 lb vector at 10 cps
6700 lb vector at 30 cps
17000 lb vector at 60 cps

Power required for following - 208-volt 3-ph. 60 cycle motors

Hydraulic pump - 15 hp

Lubricating pumps - 1 hp

Compressed air supply (static) for amplitude control - 300 psi

Cooling water required for sustained operation

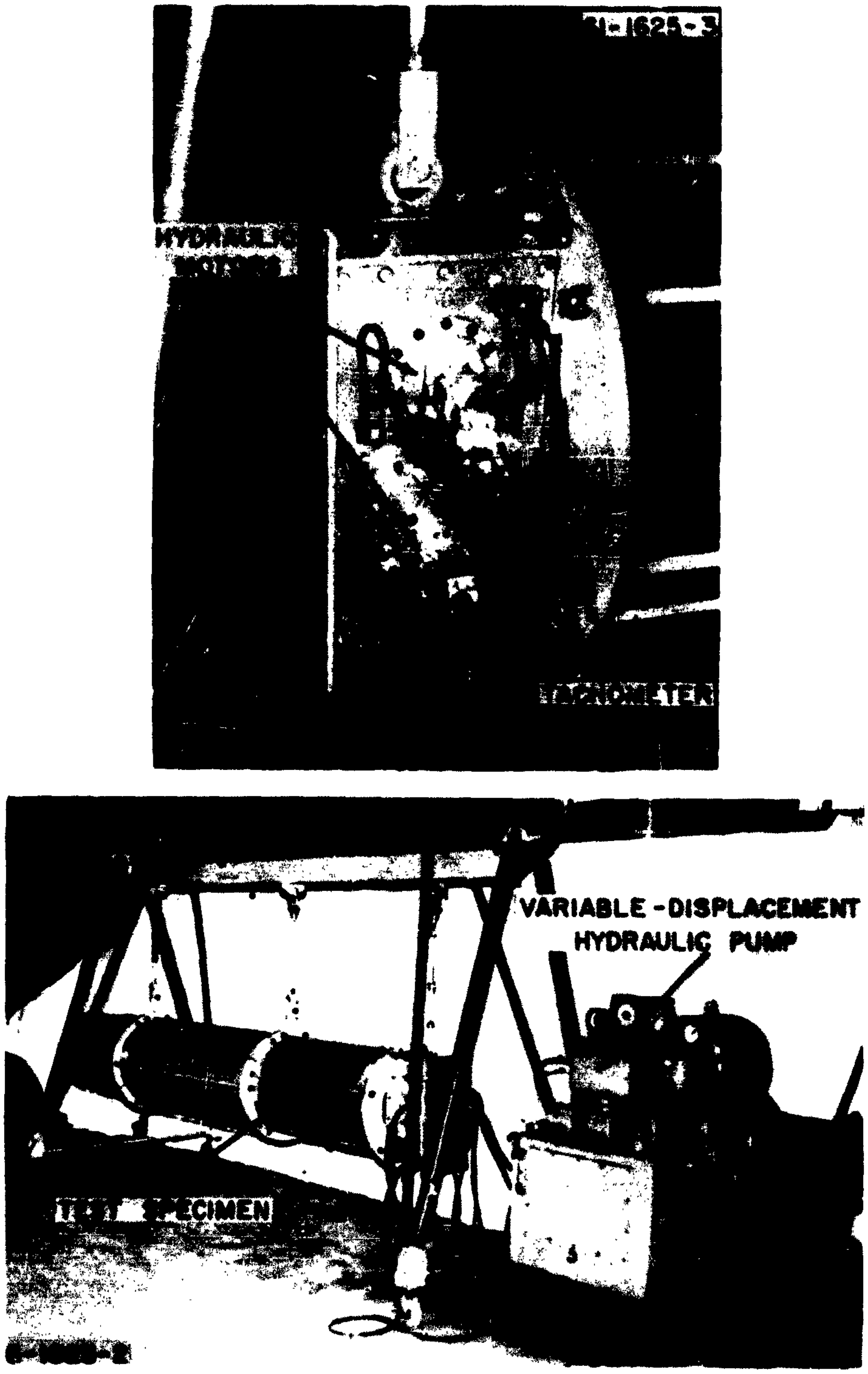


FIG. 32

ELECTRODYNAMIC VIBRATORS

The electrodynamic vibrator systems consist of an exciter unit, a power amplifier, and various control units. The alternating force produced by the exciter results from the alternating and direct current magnetic fields produced by the armature and field respectively. The exciters are mounted on trunnions and are balanced so that the loading axis may be fixed at any position between vertical and horizontal. Small light specimens may be mounted directly on the table. Heavy and long specimens require external support, especially when vibrated in the horizontal direction. The Slippery Table, figure 35, is an example of an external support. An elastic cord or link hung from an overhead support is another.

Fig. 33. MB C25H Electrodynamic Vibrator System

This system consists of the MB C25H exciter with auxiliary equipment which includes a Westinghouse FG-10, 10KW power supply and a control panel for programming frequency and amplitude. Only sine wave excitation is provided. The principal characteristics are as follows:

Max. peak force output - 3500 lb.

Frequency range - 5-2000 cps

Max. displacement - 0-1/2 in. peak-to-peak

The table is a magnesium casting with raised bosses containing 3/8 in.-16 tapped holes arranged in two circles, 8 and 16 in. in diameter with eight equally spaced holes in each.

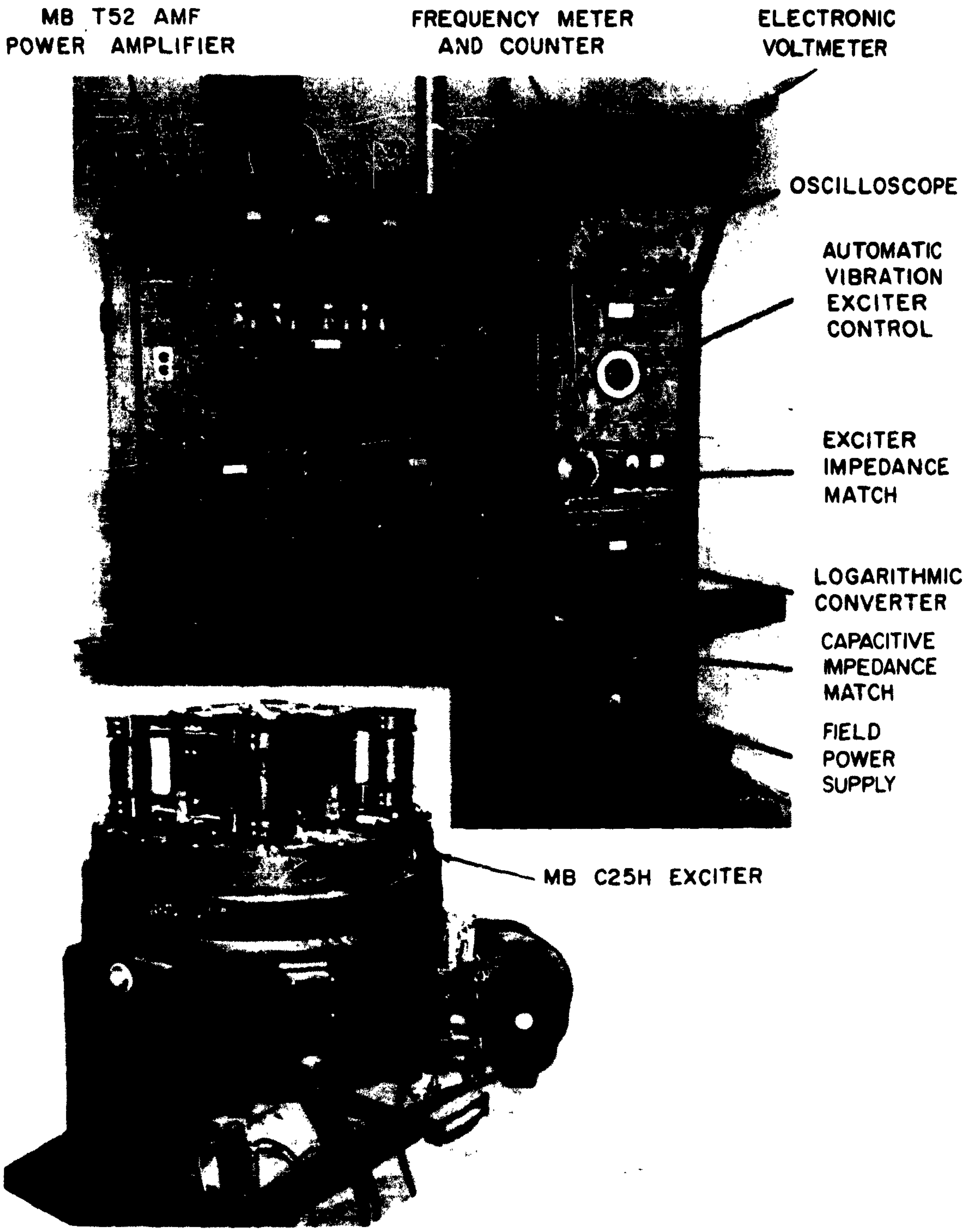

MB T52 AMF
POWER AMPLIFIER
FREQUENCY METER
AND COUNTER
ELECTRONIC
VOLTMETER
OSCILLOSCOPE
AUTOMATIC
VIBRATION
EXCITER
CONTROL
EXCITER
IMPEDANCE
MATCH
LOGARITHMIC
CONVERTER
CAPACITIVE
IMPEDANCE
MATCH
FIELD
POWER
SUPPLY
MB C25H EXCITER

FIG. 33

Fig. 34. LING Electromagnetic Vibrator System

This system consists of a LING-CALIDYNE Model 246 shaker with LING Model PP-40/60 power amplifier and control equipment for producing either sine or random excitation. The controls include a 26-channel equalizer-analyzer system for random testing which is capable of being quickly set up and adjusted. Several outputs may be continuously monitored and analyzed. Also, included is an X-Y plotter and a tape loop recorder usable either for recording output or as a means of input of a prerecorded signal. Controls for sine excitation include frequency cycling and automatic gain control for constant acceleration or displacement with automatic cross-over.

The exciter is water cooled. The aluminum table is 16 1/4 in. in diameter and has 16 raised bosses arranged in a pattern of three squares. Each boss contains a 3/8"-16 tapped insert. The principal characteristics of the system are as follows:

Rated max. force output - 7500 lb vector for sine excitation
5000 lb rms for random excitation

Frequency range - 5-2000 cps

Max. displacement - 1 in. peak-to-peak

Max. acceleration - 90 g vector

Max. power spectral density - 0.2 g^2/cps for 150-lb specimen with 5-2000 cps bandwidth

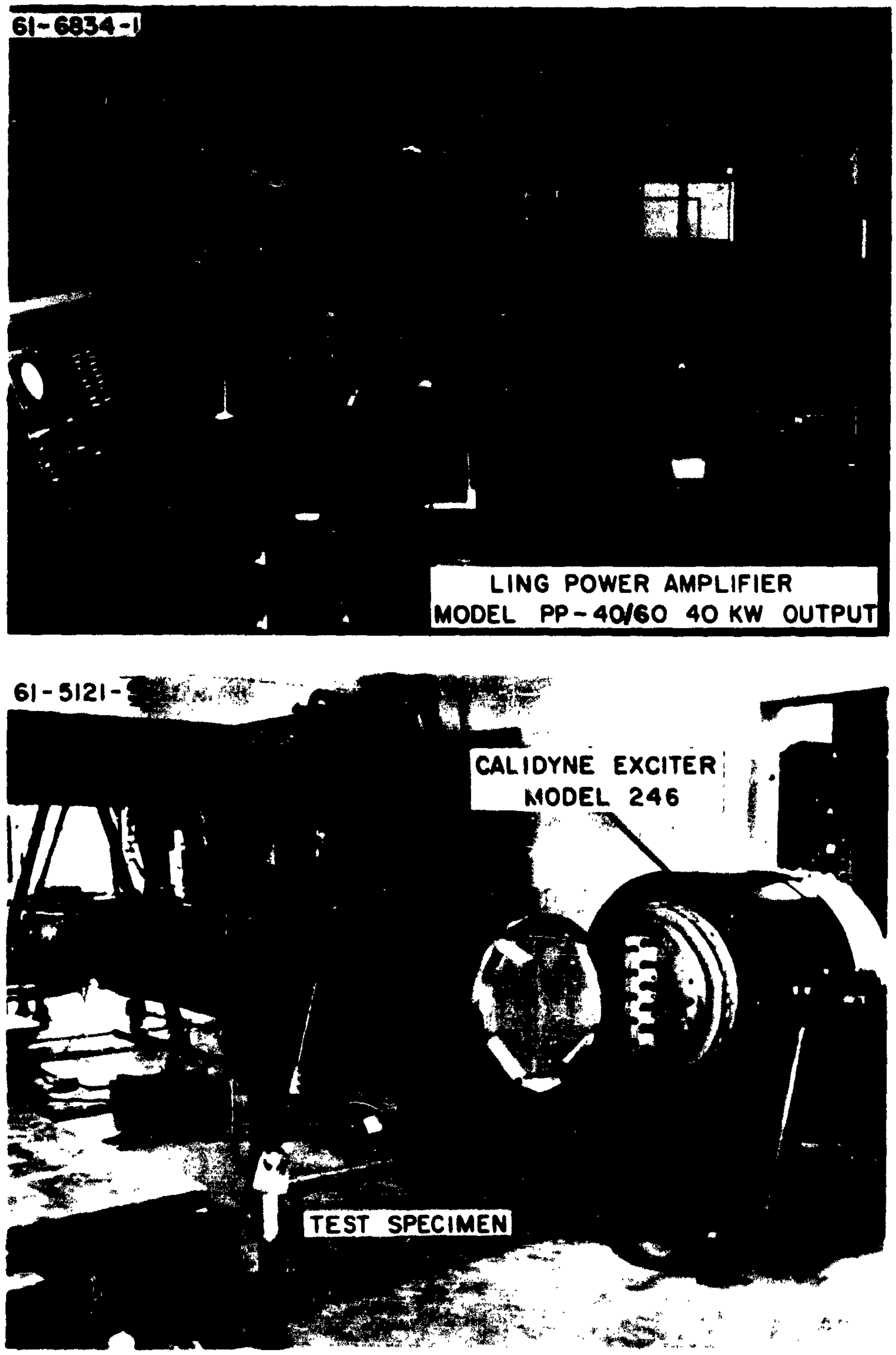

61-6834-1
LING POWER AMPLIFIER
MODEL PP-40/60 40 KW OUTPUT
61-5121-
CALIDYNE EXCITER
MODEL 246
TEST SPECIMEN

FIG. 34

Fig. 35. NOL Slippery Table

This vibration test accessory is used with the MB and LING exciters to support a heavy specimen vibrated in the horizontal direction. This support relieves the shaker armature of a transverse load which, for a heavy specimen, would strain and damage the suspension. In addition, the table provides guidance in that the mounting plate is constrained to vibrate in a horizontal plane.

The slippery table consists of a black granite block weighing 4200 lb., the top of which is finished to a plane and polished. A mounting plate carrying the test specimen is supported by the block and is rigidly attached to the shaker armature. Lubrication is provided by supplying oil under pressure through a small orifice at the center of the plate.

The granite block rests on four leveling screws and may be moved over the floor on a pair of rollers centered under the block. Thus it may be accurately positioned for use with either of the two exciters. Various mounting plates are used.

Location - Room 20-176

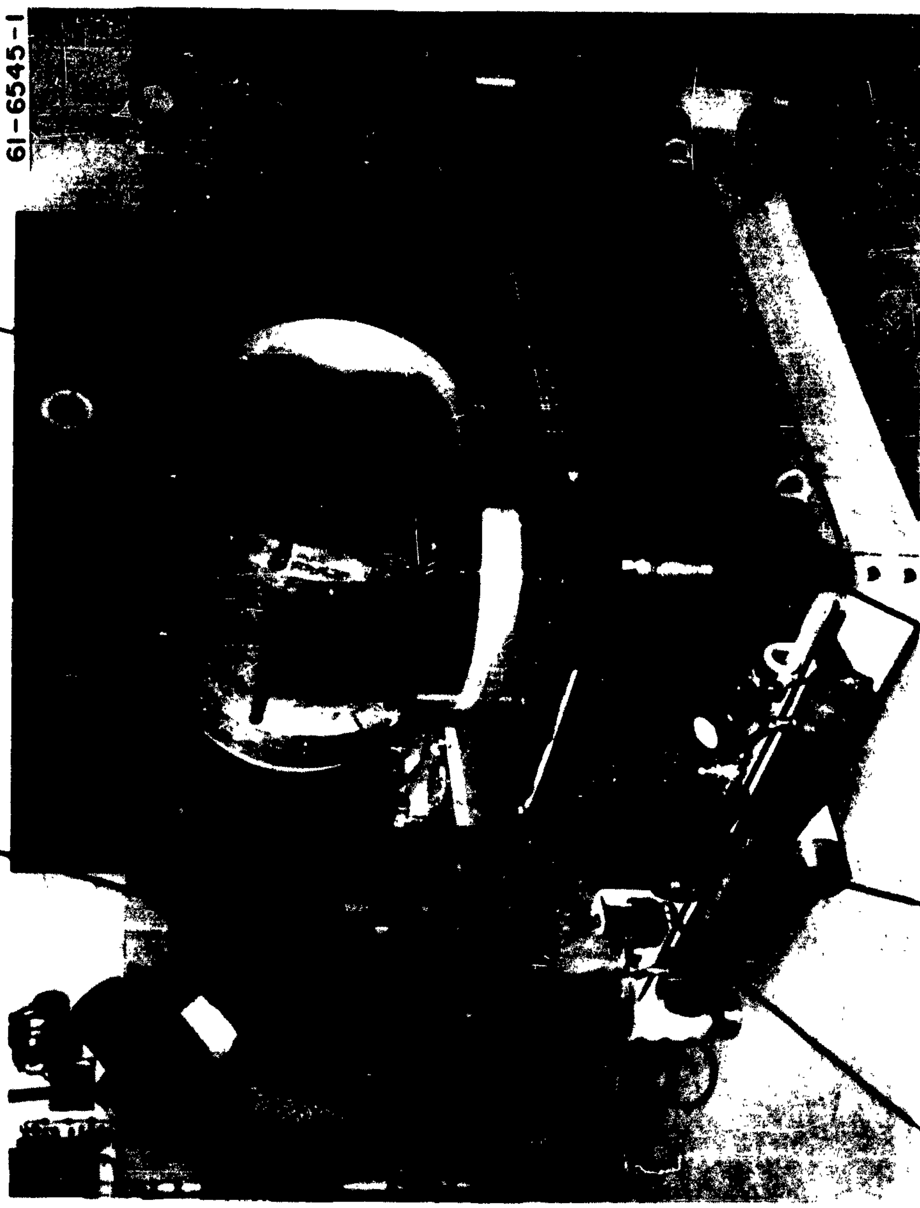

61-6545-1
SPECIMEN
EXCITER
MOUNTING PLATE
BLACK GRANITE BLOCK (4200 LB)
ROLLERS
PRESSURIZED LUBRICATING OIL SUPPLY

FIG. 35

Fig. 36. MB C31 Vibration Pickup Calibrator

This is a small exciter, with electronic power supply, used principally for calibration of velocity pickups and accelerometers. The output of a built in signal generator is proportional to velocity and is used for determining amplitudes.

Max. peak force output - 25 lb vector

Frequency range for calibration - 6-1000 cps

Max. displacement - 1/2 in. peak-to-peak

Table diameter - 1 7/8 in.

FIG. 36

Chapter 6

PACKAGE TESTING FACILITIES

Standardized tests are performed on shipping containers and crates by means of these facilities. The susceptibility to damage under drops, repeated impact, and rough handling may be determined for the package; also, the degree of protection afforded the contents. Package leakage and the effectiveness of seals may be determined. All facilities are located in Room 20-067.

Fig. 37. LAB Package Tester

This machine consists of a wooden platform driven by cams so that a point on the platform executes a circular motion 1 in. in diameter in a vertical plane. The motion of the package and the severity of its impacts with the platform and barrier depend to some extent on the frequency and the configuration of the package. The frequency may be varied between 100 and 350 cpm. The test container is placed on the platform but is not fastened to it. During each cycle there is an impact between the package and the platform and between the package and a barrier at one edge of the platform.

Platform dimensions - 5 x 5 ft.

Load capacity - 1000 lb.

FIG. 37

Fig. 38. LAB Package Drop Test Device

This device supports a package at a set level above the floor. Upon pressing a trigger the support is quickly removed by spring action, allowing the package to drop on the floor in approximately its original orientation. A steel rough handling plate is set in the floor.

Drop height - 12-48 in.

Load capacity - 150 lb.

Large crates are hung from a crane and dropped on the rough handling plate.

Fig. 39. NOL Leak Test Vessel

Shipping containers are tested for leaks by immersing them in water inside this vessel, evacuating the air from the space above the water and watching for bubbles. The vessel is evacuated by means of a converted steam ejector. Inside dimensions of vessel - 30 1/2 x 30 1/2 x 40 1/2. Operating range for vacuum - 0-20 in. mercury below atmospheric pressure.

9-929-6

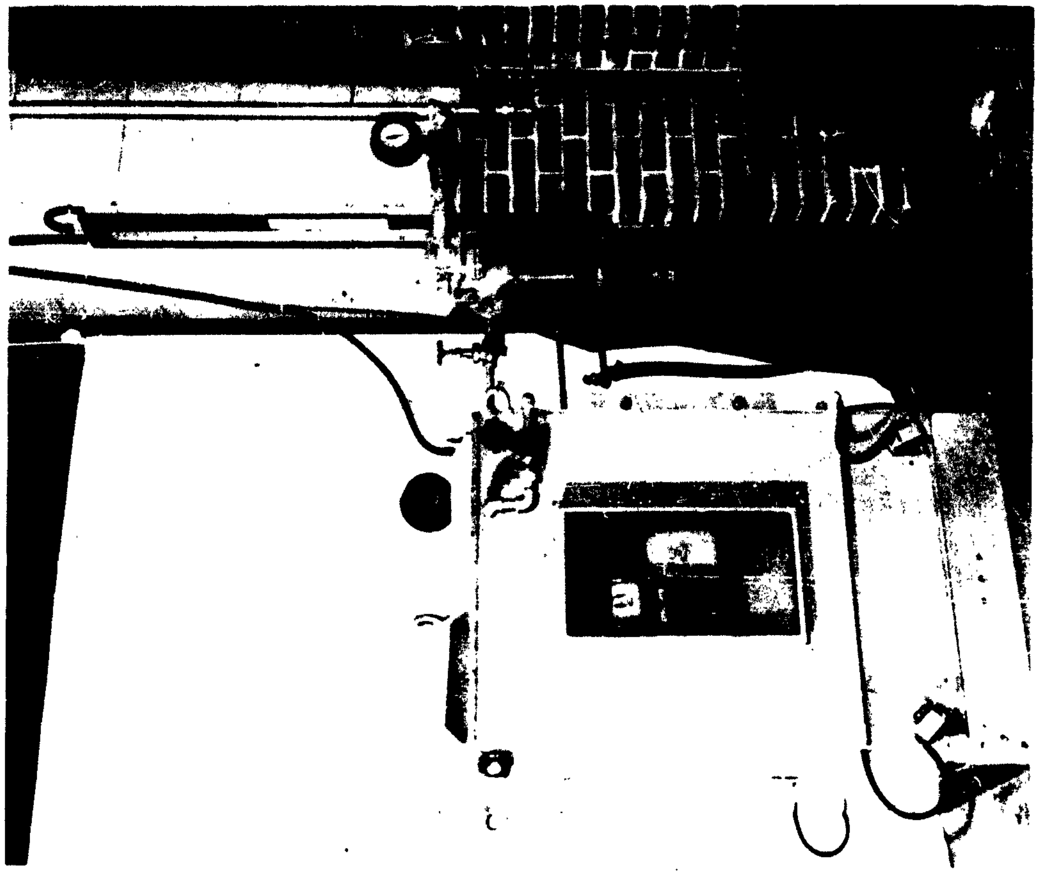


FIG. 39

9-929-9

FIG. 38

Chapter 7

PRESSURE

SIMULATION OF DEPTH AND ALTITUDE

The pressure facilities are for the purpose of simulating depth in water or altitude in air. Some of the chambers described under Temperature and Humidity also simulate altitude. Visual observation may be maintained by means of windows in some vessels and by a closed link television system in the largest. Where it is necessary to control temperature during a pressure test, provision is made for conditioning the water in advance in some vessels. Small vessels may be placed in a temperature chamber for conditioning. Frequently the specimen is temperature conditioned separately then quickly mounted in the vessel and subjected to pressure. Wires may be brought through stuffing boxes in all vessels for monitoring actuation of mechanisms, pressure switches, etc. The facilities shown are the most noteworthy and illustrate the pressure test capabilities of the Division. Various other standard test pots are not shown.

Fig. 40. NOL 8-x-30-ft Horizontal Pressure Vessel

This vessel is unique in that it combines large size with great range of pressure, versatility, and excellent control. The largest mine or torpedo can easily be accommodated. Means are provided for automatically programming the pressure or simulating altitude to produce a definite function of depth with time as in ordnance sinking or to maintain constant depth. After the vessel is filled with water either water or compressed air may be used as the control medium. The controls will automatically maintain the programmed pressure even with volume change of the specimen or emission of gas by the specimen. For altitude simulation the controls will provide a definite function of altitude change with time. The water may be preheated or precooled in the Sea Water Tank and pumped into the vessel. The door of the vessel is raised or lowered by means of a hydraulic ram and is sealed by rectangular rubber gaskets. Hydrostatic pressure is applied to the back of the gasket to effect a preliminary seal. The gasket is then self-sealing under pressure subsequently built up in the vessel.

Internal dimensions - 100 in. diameter by 382 in. length
(90 x 360 in. unobstructed)
Capacity - 14,900 gal
Medium - water or air

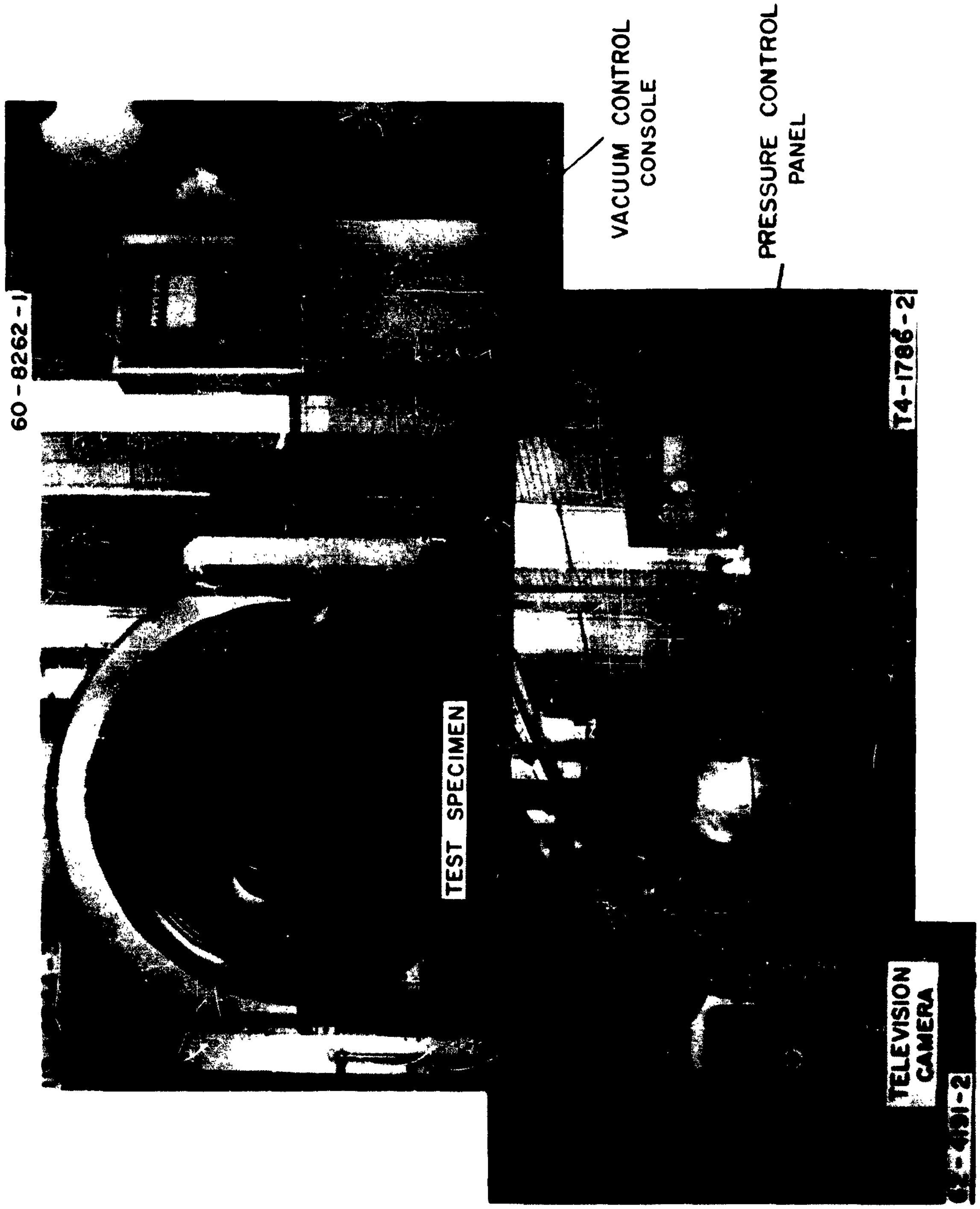

VACUUM CONTROL CONSOLE
PRESSURE CONTROL PANEL
60-8262-1
T4-1786-2
TEST SPECIMEN
TELEVISION CAMERA

FIG. 40

Pressure range - 0-1250 psi (0-2800 ft equivalent depth)

Max. rate of increase in pressure - 50 psi/sec by pumping water

Altitude range - 0-120,000 ft

Max. rate of change of altitude - 5000 ft/min

Range of controlled initial temperature of water - 30°-90°F

Observation - Visual through windows of 5 1/4 in. viewing diameter, or closed-link television with internal camera. Elevation and pan of camera are controllable from outside by flexible shafts. Internal underwater lights of 13.5 KW power are available.

Communication - seven stuffing boxes for 3/8-in. cable

Entrances - five 12-in. ASA 900 psi flanges for miscellaneous entrances

Reports - NAVORD REPORTS 3586 and 3924

Manufacturer of facility - vessel, Babcock and Wilcox Co.
door, Adamson United Co.

Location - Assembly area, Bldg 20

Fig. 41. Vertical Pressure Vessel

This is a medium-size cylindrical vessel with axis vertical. An overhead crane facilitates handling the lid and specimen.

Internal dimensions - 30 in. diameter by 108 in. length (27 1/2 by 93 in. unobstructed)

Medium - water or air

Max. pressure - 1250 psi

Controls - usually manual pressure controls are used but the automatic controls of the 8 x 30 ft horizontal vessel may be connected.

FIG. 41

Communication - five stuffing boxes for 3/8 in. dia cable

Manufacturer - vessel, Babcock and Wilcox Co.
cap, Adamson United Co.

Location - Assembly Area, Bldg. 20

Fig. 42. NOL Rotating Vessels

These are small cylindrical vessels mounted on trunnions and equipped with locking lids of the bayonet type. The specimen is usually mounted on either side of a baseplate which is bolted to the bottom of the lid. An aperture in the lid permits specimens to be mounted on top of the baseplate or to extend through it. The vessels are filled partially or completely with water before a test. A simulation of the sinking of ordnance to a definite depth in water may be obtained by simultaneously rotating the pot to bring the specimen in contact with the water and pressurizing the vessel with air. The vessels are rotated by means of remotely controlled positioning motors. The water and specimen may be separately temperature conditioned in advance.

Inside diam - 9 in.

Inside length - 28 1/2 in.

Max. diam of baseplate aperture - 6 in.

Max. working pressure - 2000 psi

Temperature range in vessel - 28-90°F

Location: 20-126

FIG. 42

Fig. 43. NOL Weapon A Vessel

This small high-pressure vessel was constructed as a test facility for a particular weapon but is now extensively used as a portable pressure test facility. The pressure medium may be water or air. A special dolly is available for transporting the vessel.

Inside dimensions - 15 in. diam by 60 in. long

Max. working pressure - 4000 psi

Fig. 44. NOL Ocean Flow Simulator

By means of this device artifical sea water at controlled temperature and pressure is circulated at a controlled velocity past stations where test mechanisms are installed. Some mine mechanisms such as clock starters and extenders utilize soluble washers. A satisfactory simulation of ocean environment may require that the dissolved material from these washers be carried away as by ocean currents.

Max. working pressure - 67 psi

Max. velocity of flow - 7 knots

Temperature range - 32-100°F

No. test stations - 6

Location - 20-045

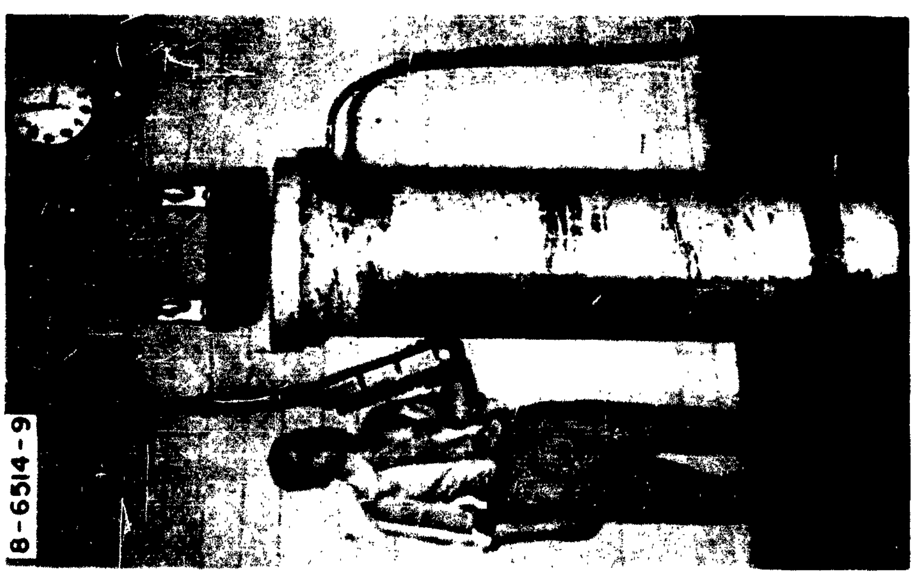


FIG. 43

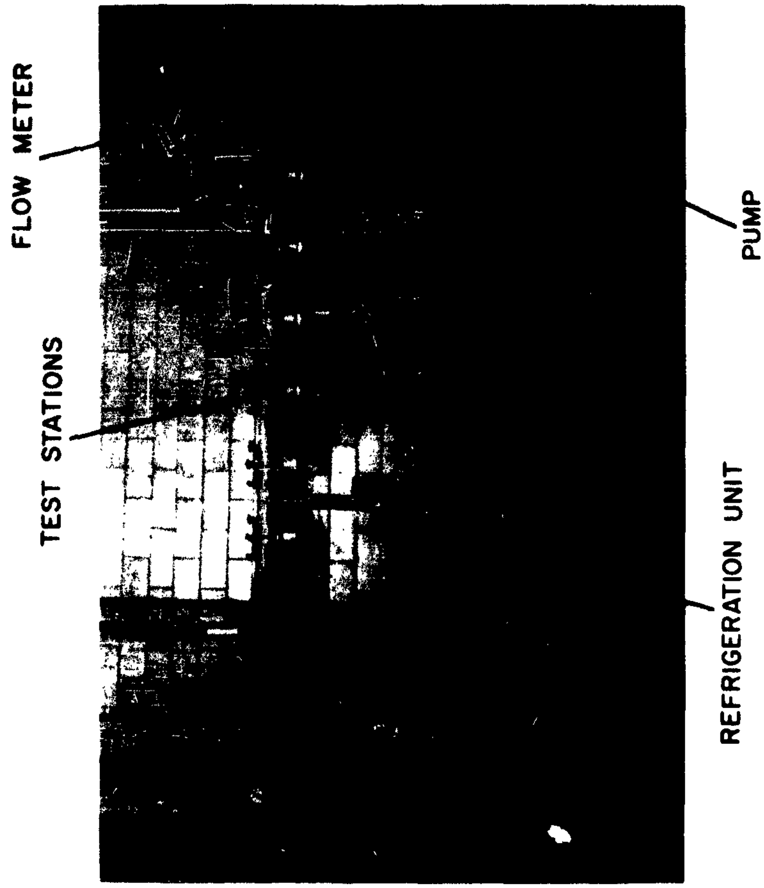


FIG. 44

Fig. 45. NOL Underwater Explosion (UWX) Machine

Simulates by mechanical means, shock experienced by underwater ordnance as a result of an underwater explosion. Test item is placed in a vertical water-filled tube pressurized to simulate depth. Simulation of pressure wave and bubble pulse is effected by piston-actuated hammers at the bottom and at the top respectively. The maximum shock wave which can be produced is equivalent to that from a detonation of 300 lb of high explosive at a distance of 30 ft.

Max. dia of test specimen - 12 in.

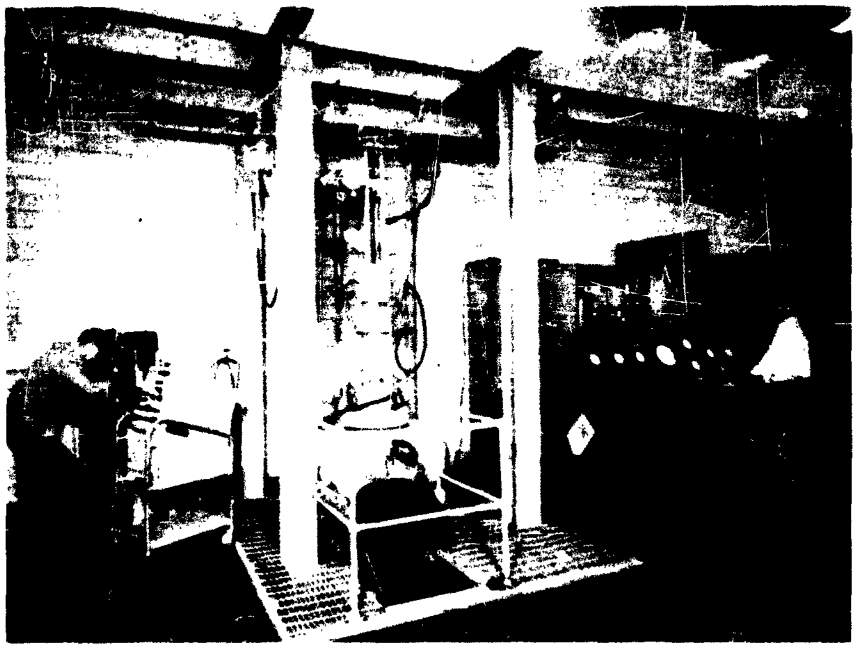
Max. static pressure - 1000 psi (2250 ft depth)

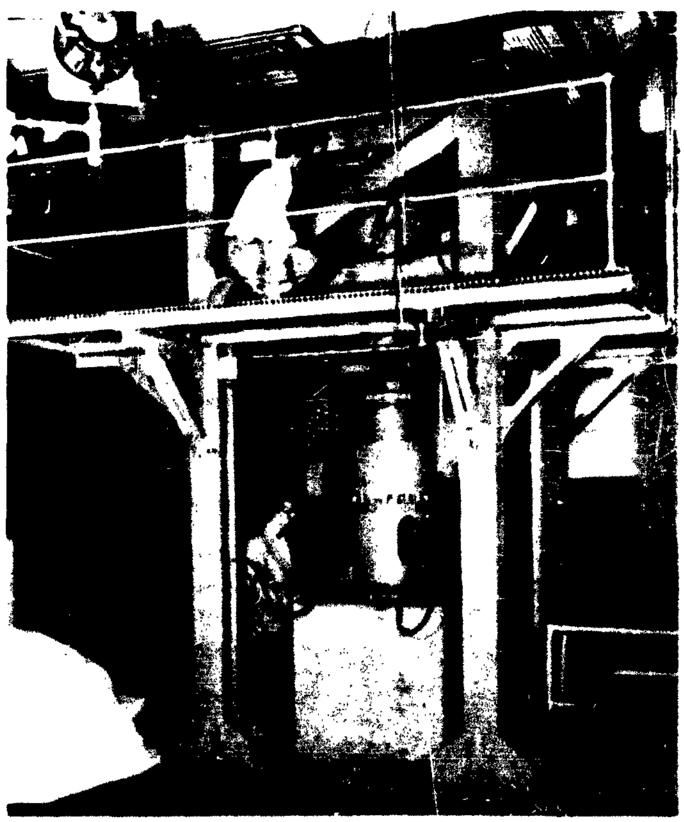
Max. shock wave pressure - 4000 psi

Controlled parameters - depth, peak pressure, duration and rate of decay of pressure wave

Location - Room 20-126

T6-5454-2





T6-5454-3

FIG. 45

Fig. 46. Digital Pressure Readout and Recording System

By means of this instrumentation a varying pressure may be continuously displayed on a counter and printed on a paper tape. The system employs commercial components. Three ranges of pressure may be used, 0-25, 0-1500, and 0-2500 psi differential. Readout may be made directly in any desired unit of pressure by the use of a conversion factor. As many as five readings per second may be taken and an accuracy of 0.05 percent at the maximum pressure is obtainable.

Location - 20-126

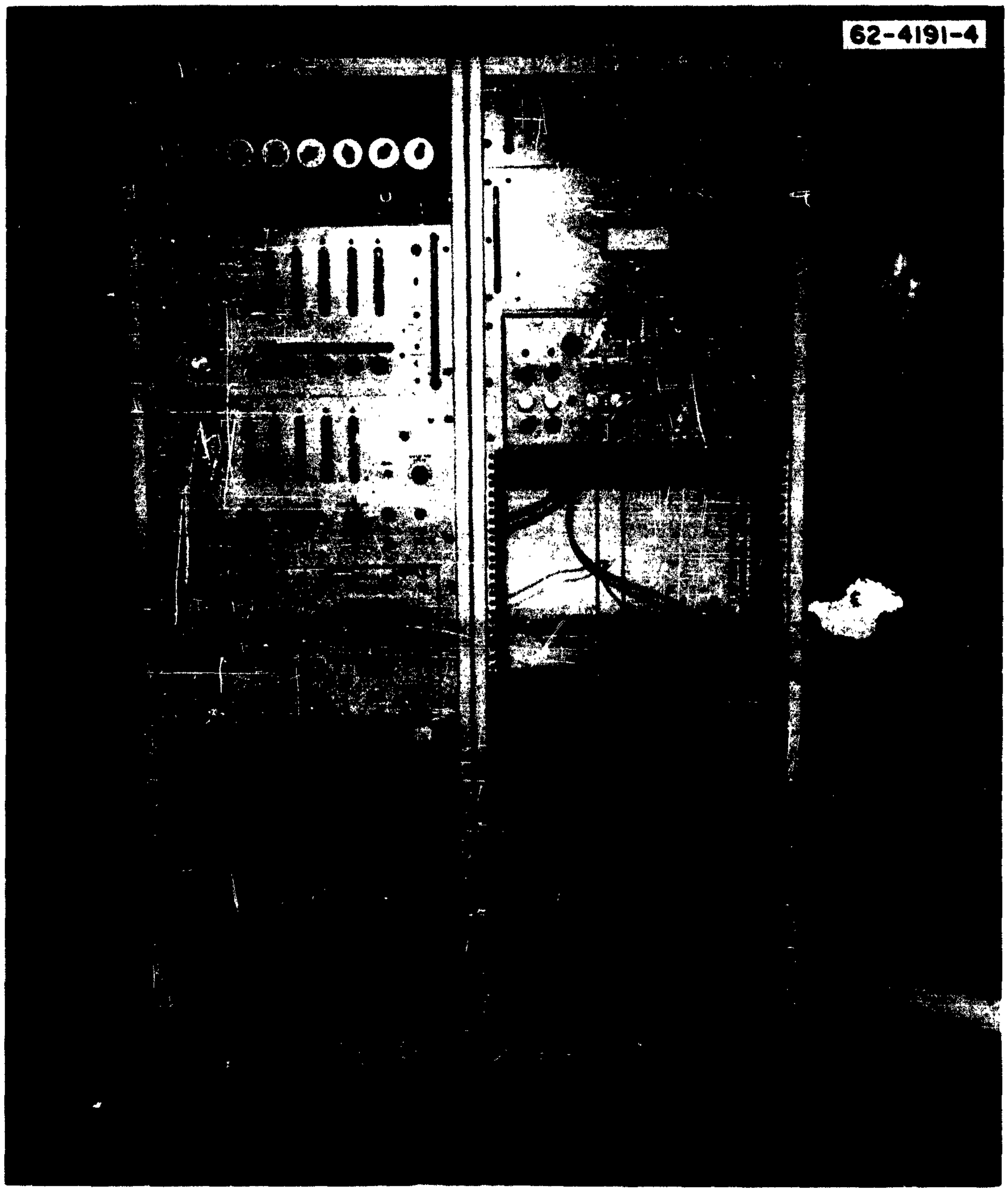


FIG. 46

LEAK DETECTION

The detection of leaks in cases, housings, enclosures, and seals in general is a function of the Pressure Group. The methods used are non-destructive and fall into two classes. In one class a trace gas, either Freon or helium, is introduced at one side of the seal or closure, a pressure difference is created across the seal and any leakage of the trace gas through the seal is detected by sensitive electronic means. This is the most sensitive method. It is relatively inexpensive and can be performed throughout a wide range of temperatures.

In the other class the external air pressure is reduced below the internal, or the internal increased above the external, the container is immersed in water and leaks are detected by observing bubbles. Under this method, weapon cases are sometimes pressurized to about 15 psi, then held under water in the Ocean Water Immersion Tank to detect bubbles.

Leakage is usually determined in the course of making hydrostatic pressure tests of ordnance. The presence of water inside a mine case can be detected by electrical conduction through a medium such as blotting paper which absorbs and retains water.

Fig. 47. Consolidated Leak Tester Model 24-101A

This facility is a simplified mass spectrometer sensitive to minute traces of helium. In operation, a pressure difference is set up across the closure or seal. The location of the leak can be determined by moving a probe around the seal. A quantitative determination of the total rate of leakage can be made if the concentration of helium inside the closure is known. In this case the specimen is usually placed in a bell jar which is evacuated. The amount of helium leaking into the vacuum over a period of time is measured. If the gas inside a specimen is pure helium a total leak rate as low as 1×10^{-4} to 6×10^{-8} std cc/sec can be measured.

Location - 20-158

FIG. 47

Fig. 48. General Electric Halogen Leak Detector Type 4

Freon 12 is the trace gas used with this detector. The equipment is portable and leaks can be detected by either the probing or the total leak rate method. A leakage rate as low as about 1×10^{-6} std cc/sec can be measured.

Location 20-033.

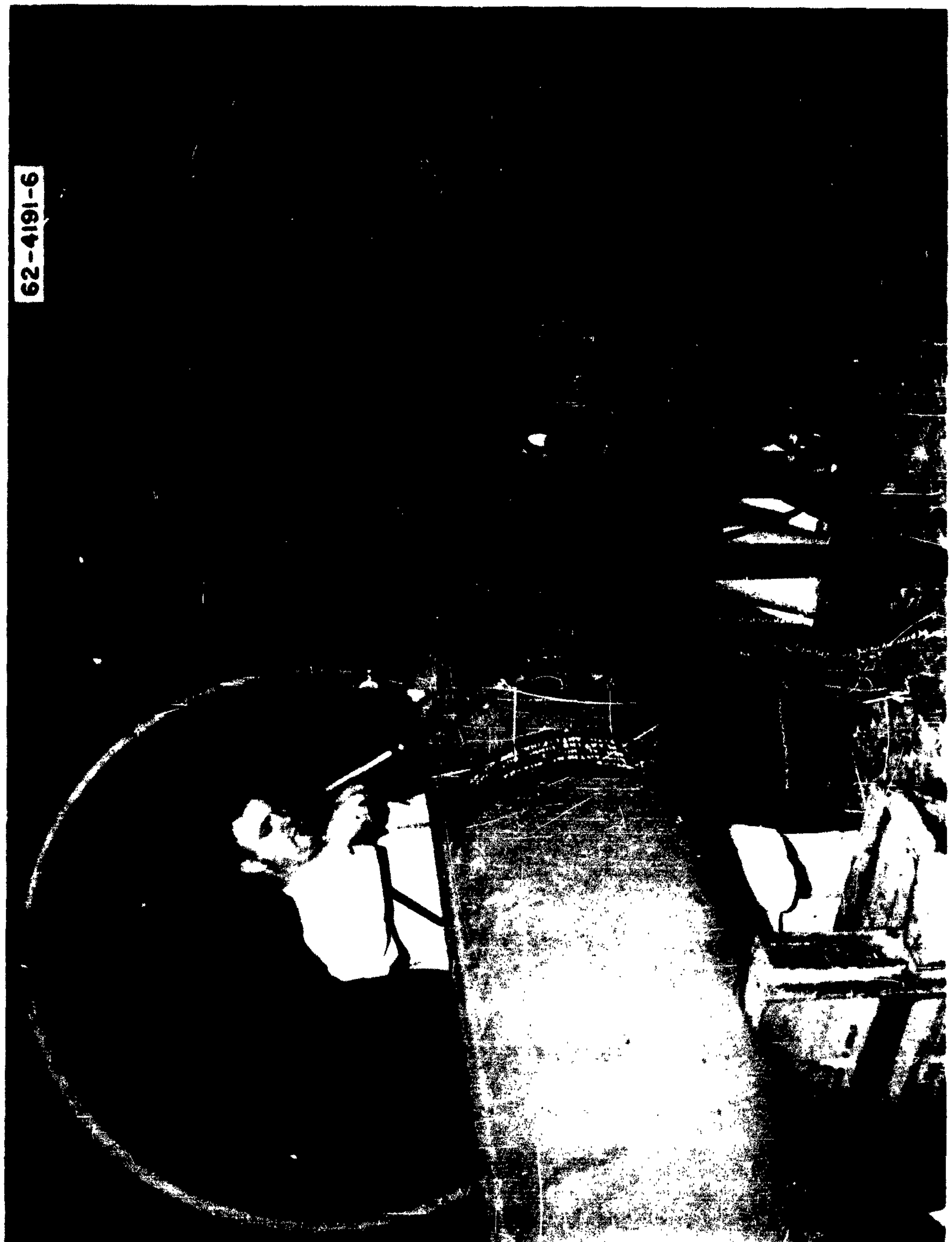


FIG 48

Fig. 49. NOL Pressure/Vacuum Bubble Leak Tester

This device consists of a glass bell jar with a plexiglas cap and a safety shield of the same material. The jar is partly filled with water. A test specimen of a small enclosure or case is attached to a rack, the elevation of which is adjustable from the outside. Usually the specimen is pressurized in the air space above the water at 10 psi, then immersed in the water and the space above the water is immediately evacuated. Bubbles indicate leaks. The test is non-destructive because water does not penetrate the seal. Leakage at a rate as low as 1×10^{-4} std cc/sec can be detected within a practical observation period. Another bubble leak tester used for packaging is shown in Figure 39.

Inside diameter - 15 in.

Location - 20-033

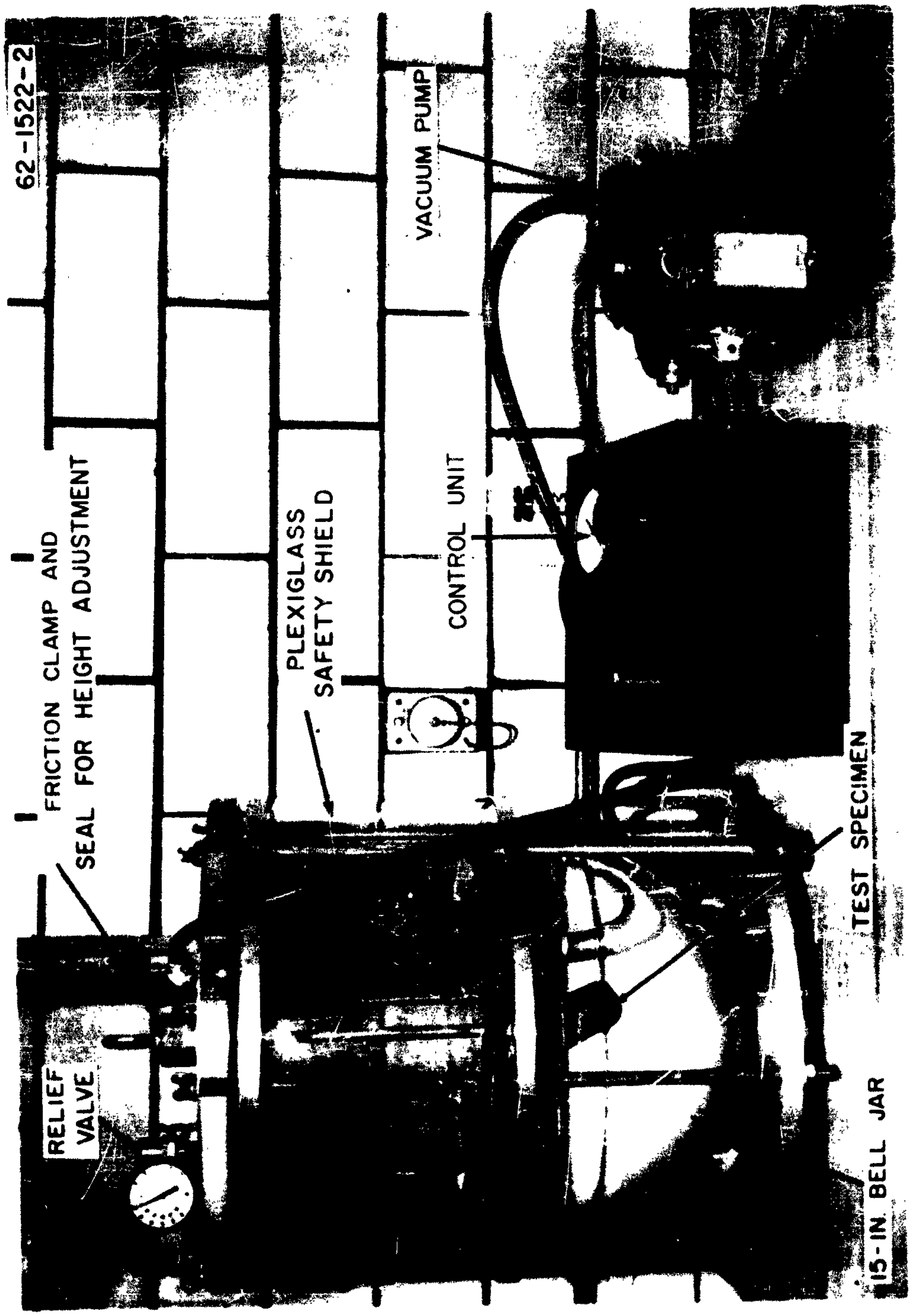

62-1522-2
VACUUM PUMP
CONTROL UNIT
PLEXIGLASS SAFETY SHIELD
FRICTION CLAMP AND SEAL FOR HEIGHT ADJUSTMENT
RELIEF VALVE
TEST SPECIMEN
15-IN. BELL JAR

FIG. 49

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REPORT DATE	2 August 1962	Ø862	CIRCULATION LIMITATION OR BIBLIOGRAPHIC		
			BIBLIOGRAPHIC (SUPPL., VOL., ETC.)		

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Facilities	FACI	Vibrators	VIBR		
Capacity	CAPC	Mechanical	MECA		
Performance	PERF	Electromagnetic	ELEM		
Temperature	TEMP	Package	PACA		
Humidity	HUMI	Pressure	PRES		
Altitude	ALTT	Depth	DEPT		
Immersion	IMMR	Simulation	SIMU		
Corrosion	CORR	Leakage	LEAK		
Shock	SHOC				
Impact	IMPC				

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(NOL technical report 62-30)
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This report presents a brief description with photographs of the principal test facilities of the Environment Simulation Division, NOL. Basic information on capacity and performance is included. The principle of operation is briefly explained where this is not obvious. The report is expected to be valuable for training new design and evaluation engineers of the Laboratory and in serving as a handbook while they are developing test programs.

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